THE

Seaman's Practice;

CONTAINING

A Fundamental Problem

IN

NAVIGATION,

Experimentally Verified:

NAMELY,

Touching the Compaſs of the *Earth* and *Sea*, and the Quantity of a Degree in our Engliſh Meaſures.

ALSO,

Of dividing the *Log-Line* and Reckoning the Ship's Way,

With certain TABLES and other *Rules* uſed in *Navigation*: The finding of the Currents at SEA, and what Allowance is to be given in reſpect of them.

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London: Printed for *Thomas Page*, and *William Mount*, in *Poſtern-Row*, on *Tower-Hill*, M DCC XXXII.

To the Reader.

THE Circuit of the Earth and Sea (as the Circumference of every Circle,) contains 360 Degrees, by which Degrees the Distances thereon are measured, so that the Knowledge of the Quantity of such a Deg. in our known Measures, is a Fundamental Principle in Cosmography and Navigation, as upon which is grounded the Reckoning of the Ship's Way or Distance run. For though a Mariner, being in his Voyage on the vast Ocean, hath sometimes three things to certify him where he is, and how to shape his Course to his desired Port, namely his Lat. Course, and Dist. and sometimes a fourth, namely, some near Conjecture of his Long. by the Variation, or otherwise, yet oftentimes (as in close Weather) he hath nothing but his Course and Dist. other whiles only his Lat. and Dist. is his Chief Guide in falling in with his intended Port. I know it is usual to allow near 7 fath. or 41 $\frac{2}{3}$ Feet to a Knot; and so many of those Knots as run out in half a Min. so many Miles they count the Ship's Way to be in an Hour And if in half a Min. she run 41 $\frac{2}{3}$ Feet, then in 60 Min. or an Hour, she runs 5000 Feet, and thus they account 5000 English Feet, or 1000 Paces to be a Mile, and 60 of those Miles to be a Deg. such as the whole Circumference in any Great Circle is 360. But how is this known to be true? If it be answered, that it is known to be so by Experience; than I would know farther by what Experiment this was found to be so; where and by whom made? I press this so much the rather, because I am perswaded we have at this Day as many excellent Navigators in this Kingdom, and as great Voyages performed, as from any other Place in the World; and I should be glad to hear of the Experimental Resolution of this Problem by some of them, though it were but in running 8 or 10 Degrees near the Meridian; for so I doubt not but that which I have here written thereof, would receive farther Confirmation and better Entertainment, than haply it will now, being so much different from the common Opinion: and the Arts of Navigation and Cosmography would be much more perfected in a short time. For one Error (as a fruitful Mother) is oftentimes the Cause of more; and so the removing of one is occasion of removing others, especially when they do mutually support one another. As we shall here shew how the Error in the Projection and Use of the common Sea-Chart is supported by this Error of accounting only 300000 of our Feet to a Degree: and this in like sort upheld by that, so that they will stand or fall together: and surely that had fallen long since, being so manifestly convinced, if it had not been upheld by this. For the confuting of that (I mean the common Sea-Chart) it was sufficient to know that the Earth and Sea make one spherical Body. But in disproving and rectifying this, it is necessary to know moreover what is the Quantity of that spherical Body. And to that end it was necessary

to

to make a ſenſible Application of our known Meaſures to a determinate Part of the Whole, that ſo the Quantity of that determinate Part being known, and the Proportion thereof to the Whole, the Quantity of the Whole might alſo be diſcovered. And this I have endeavoured in the Experiment following, which if I have not handled ſo exactly in all Points as ſome would deſire (that requiring more Time and Charge than I could well beſtow, yet I doubt not but it will be found that I have come very near the Truth. Some haply will cenſure me, for being my ſelf at the Expence to make ſuch an Experiment. But I was as frugal in it as I could, adding Pains and Induſtry to ſave Expence. I came up in ten or eleven Days, and had other neceſſary Occaſions to lead me from one Place *to the other, and did this, as a thing falling opportunely in my Way: But indeed, as in all other Parts of Learning, ſo in the Mathematicks, eſpecially in their Application, or middle Mathematicks (as ſome call them) it is neceſſary with Speculation, to join actual and experimental Practices; the former being empty and uncertain without theſe: It is true that the Mathematicks afford large Fields of delightful Speculations, wherein a Man might walk far with much Pleaſure: But if from ſo many fair Flowers he brings home no Honey, or from ſuch large Fields no Sheaves; I mean if he bring not thoſe Speculations, to ſome uſeful Practices, neither himſelf nor others are like to receive much Fruit by them. But this indeed cannot be effected without more Labour and Difficulty; yea, ſometimes it requires machanical and bodily Exerciſe, which ſome eſteem too mean and unworthy to ſtoop unto. But for my own part, I acknowledge to have had my Living and Maintenance by the Mathematicks, and not by Speculation only, but rather by my* Practice *therein, and therefore alſo I deſign what in me lies to make them fruitful to my ſelf and others, and to that end have ſpent in ſome principal parts of the Mathematicks, near as much Time and Means in experimental Practices and Concluſions, as in the Speculation. Moreover, conſidering that this particular Experiment was propoſed above* 30 *Years ſince by our Country-man Mr.* Edward Wright, *to invite ſome to the Trial of it, as a thing which he would have done himſelf if he had found ſuch Furtherance and Opportunity as he deſired, which it ſeems it did not, nor any other ſince that Time: Rather than ſo noble and ſo neceſſary a* Problem *ſhould longe reſt unreſolved, I took the Opportunity offer'd, hoping it may be an Occaſion to whet on ſome others to do the like. This with ſome other Things, which I conceived to be wanting in the Practice of* Navigation, *I have handled in this enſuing Treatiſe, which I commend to your Friendly Acceptance. Farewell.*

CHAP. I. *The common Opinion touching the Compaſs of the Earth, and Quantity of a Degree on the ſame.*

IT is a common received Opinion in *England* (and the like is in other Places) that allowing 5 of our *Engliſh* Feet to a Geometrical Pace, 1000 of thoſe Paces make an *Italian* Mile, and 60 of thoſe Miles in any Great Circle, upon the Spherical Surface of the Earth or Sea, makes a Degree; and thus it is ſuppoſed, that a Degree contains 60 Miles, 60000 Paces, or 300000 of our *Engliſh* Feet, and by ſuch Miles do Mariners, in their Voyages by Sea, keep their Reckonings. And becauſe the whole Circumference of a Circle is 360 Degrees, therefore the Compaſs of the Earth, according to this Opinion, ſhould be 21600 ſuch *Italian* Miles, 21600000 Paces, or 108000000 of our *Engliſh* Feet. Whence this Opinion came, or upon what Experiment it ſhould be grounded, I cannot certainly ſay: It may ſeem to be taken, or rather miſtaken from *Ptolomy*, who ſaith, there are 500 *Stadiums* in a Degree; the ſame was before affirmed by *Marinus Tyrius* of whom *Ptolomy* ſpeaking in the 11*th* Chap. of his Book of *Geography* hath theſe Words, *Sed in hoc, quoque recte ſentit, partem uncam qualium eſt Circulus maximus tricentorium ſexiginte, quinginta in terra conſtituere Stadia, id enim confeſſis demenſionibus conſonum exiſtit.* Now a *Stadium*, not only amongſt the *Greeks* but as appears by *Herodotus* amongſt all other Nations of *Aſia*, and in *Egypt*, did conſiſt of 600 Feet, or 100 *Orgays*, an *Orgay* containing 6 Feet or 4 Cubits, as our fathom doth, the ſame alſo is teſtified by *Suidas* and others: So that a Degree cotaining 500 *Stadiums*, and every *Stadium* 600 Feet, it follows, that a Degree muſt contain 300000 Feet, exactly agreeing in Number with the common received Opinion in *England*, which therefore may ſeem to be hence derived, and would alſo receive much Confirmation hereby, (he being an Author of ſuch approved Credit) if it could be approved that our *Engliſh* Feet were exactly equal to the *Egyptian* or *Alexandrian* Feet, where *Ptolomy* wrote. Otherwiſe, that being true that ſo many of their Feet make a Degree; it will follow, that if ours be greater, there be fewer of them contained in a Degree; if leſſer (as undoubtedly they are) there muſt be more of them contained in a Degree.

Philander, in his Commentary upon the third Chapter of the third Book of *Vitruvius*, hath expreſſed the Quantity of the Ancient *Roman* Foot, where (by a competent Allowance for the ſhrinking of the Paper, being printed wet) it may probably be gathered that it was ſomething longer than our *Engliſh* Foot. But the *Alexandrian* and *Egyptian* Foot was much greater; For according to *Hero Mechanicus* 5 *Alexandrian* Feet were equal to 6 *Roman* Feet: ſeeing then the ancient *Roman* Foot was ſomething greater than ours, the *Alexandrian* muſt needs be much greater than ours. So that whereas *Ptolomy* ſaith, there are 500 *Stadiums* in a Degree; and as we have ſhewed, a *Stadium* did conſiſt of 600 Feet, theſe being *Egyptian* or *Alexandrian* Feet, as it is moſt probable, being the Place where *Ptolomy* lived, there muſt be a far greater Number of our Feet in a *Stadium*, and ſo in a Degree; whence it is evident, that there is no ſufficient footing for this common Opinion in the Aſſertion of *Ptolomy*. Neither

Neither doth the Practice and Experince of Mariners in their Voyagse at Sea, prove it; for there is no Reckoning or Experiment at Sea ſet down by any (that I have ſeen) to confirm it. And though it be true, that in ſailing between two Places that lie near to one and the ſame Parallel, they ground their Reckoning chiefly upon this Suppoſition, that 300000 of our *Engliſh* Feet makes a Degree; yet can they ſeldom or never by thoſe Reckonings diſcern the Error, the rather for that they have been, and for the moſt part are ſtill kept upon the Plain or common *Sea-Chart*, which makes a Degree in any Parallel equal to a Degree in the Equinoctial, and ſo makes a Degree in any Parallel to contain 300000 Feet; and it's true, that in ſome Parallel a Deg. doth contain only 300000 of our *Engliſh* Feet; namely, about that Parallel which is in Lat. 35° (as we ſhall farther ſhew hereafter) near unto which have the principal of our Eaſtern and Weſtern Voyages been made. And thus though this Opinion of 300000 Feet in a Deg. and the Projection of the common *Chart*, be both erronious; yet becauſe the Error of the one doth ſomewhat ſalve the other, they could not be eaſily diſcern'd by Experience only.

This Opinion of 300000 *Engliſh* Feet to a Degree, may ſeem alſo to be ſome thing confirmed by an Obſervation made by our Countryman Mr. *Edward Wright*, upon Mount *Edgcomb* near *Plymouth*, of the Semi-diameter of the Earth, which he hath ſet down in his Book, *Of the Correction of Errors in Navigation*, Chap. 15. where he finds the Semidiameter to be 18312621 of our Engliſh Feet; whence it may be gathered, that in a Degree of a great Circle of the Earth, there ſhould not be full out 300000 of our Feet. But the way by him then uſed, tho' it is very fit for the end whereunto he there applies it, namely, to find the dripping or depreſſion of the apparent Horizon beneath the true, according to the Heighth of the Eye above the Water; yet it will be eaſily granted to be an exact way for finding the Semidiameter, and conſequently the Circumference of the Earth, or a Quantity of a Degree on the ſame; and ſo he ſays there, that he uſed that way, becauſe he wanted Opportunity to put in practice a more exact way. Wherefore for the farther Satisfaction of my Self and others in this Point, and chiefly for the neceſſary Uſe it hath in the Practice of Navigation, I have made the Experiment following, that ſo the Quantity of a Degree, and of the whole Compaſs of the Earth might at leaſt wiſe be nearly known in our Engliſh Meaſures.

CHAP. II. *An Experiment made for finding the Quantity of a Degree, and ſo the Circumference of the Earth and Sea, in our known Meaſures.*

HAving Occaſion to be in the City of *York*, about the beginning of *June*, *Anno* 1635, I made there ſeveral Obſervations of the Meridian Altitude of the Sun, the laſt of which was made the 11th of *June*; the Sky was every of thoſe Days ſomething overcaſt at Noon, yet not ſo much but that an Obſervation was moſt made to a near Scantling: And becauſe the laſt of thoſe Obſervations might be fit for the preſent Occaſion, and that Day was as clear as any of the other, we will here eſpecially make Uſe of that, being as followeth.

Upon the 6th of *June* 1635, I made an Obſervation near the middle of the City of *York*, of the Meridian Altitude of the Sun, by an Arch of a *Sextent* of more than

than five Foot Semidiameter, and found the apparent Altitude of the Sun that Day at Noon to be 59 deg. 33 min.

I had alſo formerly upon the 11th of *June*, *Anno* 1633, obſerved in the City of *London*, near the *Tower*, the apparent Meridian Altitude of the Sun, and found the ſame to be 62d. 1m. And ſeeing the Sun's Declination upon the 11th of *June*, 1635, and upon the 11th of *June*, 1633, was one and the ſame without any ſenſible difference; and becauſe theſe Alt. differ but little, we ſhall not need to make any Alteration or Allowance in reſpect of Declination, Refraction, or Parallax. Wherefore ſubtracting the leſſer apparent Altitude, namely, 59d. 33m. from the greater 62 deg. 1 min. there remains 2d. 28 min. which is the difference of Lat. of theſe two Cities, namely, of *London* and *York*. Alſo by the aforeſaid Obſervation made at *York* it appears that the Lat. of that City is 53d. 58m. almoſt

But to our Purpoſe: Coming at that time from thence to *London*, I further found by Meaſure, that the Parallel of *York* is from the Parallel of *London* 9149 Chains; every Chain being 6 Poles, and every Pole 16½ of our *Engliſh* Feet; that is every Chain 99 Feet. After what manner I found this to be ſo, we ſhall further expreſs hereafter: But thus, as I ſay, I found that *York* is more Northerly than *London* by 9149 Chains: And before we have noted that theſe two Places differ in Lat. 2 deg. 28 min. therefore it follows, that 2 deg. 28 min of the Meridian of the Earth and Sea, is equal to 9149 Chains. And if accordingly we would know how many of theſe Chains are contained in 1 deg. we may find that by the Rule of Proportion, firſt reducing the Degrees into Minutes, and then ſay,

If the Difference of Latitude ——— 148 *co. ar.* 7.82974
gives ſuch a Number of Chains ——— 9149 ——— 3.96137
Then 1 Degree, that is, ——— 60 ——— 1.77815
gives of ſuch Chains ——— 3709 ——— 3.56926

and ſomewhat more, namely, 5 Feet, which reduced into Feet, make 367196; that is, 367200 Feet in a Degree, lacking 4 Feet; which here we regard not.

Thus then according to this Experiment it is evident, that 1 degree of a great Circle meaſured on the Earth, is near 367200 Feet, which in our Poles of 16½ Feet, is 22254 Poles, and about one half; and theſe reduced into Furlongs, at 40 Poles to the Furlong, make 556 Furlongs and 14 Poles; and laſtly, theſe reduced into our *Engliſh* Miles, of 8 Furlongs to a Mile, make 69 Miles, and 4 Furlongs, 14 Poles, that is 69½ Miles and 14 Poles to a Degree.

And hence, according to the moſt approved Hypotheſis of the Sphericity of this Terreſtrial Globe, we may find the Compaſs of it as followeth. But firſt you may note, that we ſpeak not here of the Compaſs of the Earth in any Parallel, or leſſer Circle deſcribed upon any ſide thereof, that being various according to the different Diſt. of thoſe Circles from their Poles, but of the Compaſs taken in the middle or greateſt thickneſs of the Globe; namely, in any great Circle, ſuch as divide the whole Globe into two equal parts, of which kind are the Equinoctial, and all the Meridians, &c. This being properly the *Perimeter* or Compaſs of a Sperical Body.

Now ſeeing a Degree is the 360 Part of the Circumference of a Circle (for any Circumference being divided actually, or by ſuppoſition, into 360 equal parts, thoſe Parts

Parts are called Degrees) if we can find how many Feet, Paces, Miles or other known Measures, are contained in one of those Degrees, then shall we easily conclude how many of the same known Measures are contained in the whole Circumference: But by the former Experiment, we find that in one Degree of a great Circle, on the Spherical Superficies of the Earth, there is contained 367200 Feet, therefore it is evident that 360 times 367200 Feet is the Compass of the whole; wherefore multiplying 367200 by 360, the Product is 132192000 Feet, which reduced into Poles, is 8011636: And these reduced into Furlongs, are 200290 Furlongs, 36 Poles; and lastly, these reduced into Miles are 25036 English Miles, and somewhat more, for the Circuit of the Earth and Sea.

If further, we desire the Diameter and Semidiameter of the Earth; Forasmuch as it is proved by *Archimedes*, that the Proportion of the Circumference of a Circle is to the Diameter thereof, almost as 22 to 7. Therefore by the Rule of Proportion, as 22 to 7, so is the Circumference of the Earth to the Diameter thereof: So that multiplying the Circumference of the Earth, namely, 132192000 Feet by 7, and dividing the Product, namely 925344000 by 22, the Quotient, namely 42061091 is the Diameter of the Earth in Feet, the half whereof, namely, 21030545 Feet is the Semidiameter of the same, being 21 Millions of feet, and somewhat more, these reduced into English Miles, as before we did the Circum. shew the Diameter of the Earth to be 7966 miles and somewhat more, and the Semidiameter 3983. And thus we have the Circum. Diameter and Semidiameter of the Earth, as also the Quantity of a Deg. of the same Circumference, in known measures of Feet, Furlongs and Miles, *&c.* There are only two things here which may seem doubtful; namely the Experiment itself, and the Hypothesis of the Sphericity of this Terrestrial Globe, consisting of the Earth and Sea; for these being admitted, the measures thence deduced, as before, necessarily follow.

Now touching the Experiment, I confess, that to have made it so exact as were requisite, and in all Points, so as I shall shew in the Chapter following, would have requir'd much more Time and Expence than my Ability would reach unto. Yet having made my Observation at *York*, as aforesaid, I measured (for the most part) the way from thence to *London*; and where I measured not I paced, (wherein thro' Custom I usually come very near the Truth) observing all the way as I came with a Circumferentor, all the principle Angles of Position, or Windings of the Way, with convenient Allowance for other lesser Windings, Ascents and Descents: and these I laid not down by a Protractor after the usual manner, but framed a Table much more exact and fit for this Purpose, as we shall after shew; so that I may affirm the Experiment to be near the Truth.

Touching the *Hypothesis*, that the Earth and Sea make one Sperical or round Body, it is generally agreed upon by all the Principal Philosophers, Astronomers, Geographers and Navigators, Ancient and Modern: Some Reasons demonstrative for the Confirmation thereof may be these. First the Eclipses, especially of the Moon, which are caused by the Shadow of the Body of the Earth, being interposed between the Sun and Moon. And forasmuch as this Shadow doth fall upon the Moon always, and upon every side Circular, and so appears to us; it is manifest by the Opticks, that the Earth, from whence it proceeds is a Spherical Body.

Secondly,

Secondly, Likewiſe the Eclipſes of the Sun, which are cauſed by the Interpoſition of the Moon between the Sun and thoſe places where it appears eclipſed; I ſay, it could not be determined when, and in what place ſuch an Eclipſe ſhould appear, and where not, if the Form of the Earth were not known: But ſeeing the places where ſuch Eclipſes happen, and where not, may be, and are uſually determined, and that upon this ground, that the Surface of the Earth, is Spherical, it is thence alſo ratified to be a Truth.

Thirdly, The Sun, Moon, and Stars do riſe and ſet, and are upon the Meridian ſooner to thoſe that are reſident in the Eaſtern parts, then to others more Weſterly, and that in a proportion anſwerable to the Roundneſs of the Earth, as the Planets and Stars are upon our Meridian at *London* ſooner almoſt by 4 Hours, than they are to thoſe that inhabit the *Summer Iſlands*, and the Confines of *Virginia* and *New-England*: And ſo in *Eaſt-India*, and other Eaſtern Regions, the Sun and Stars are ſooner upon their Meridian than upon ours, which is manifeſt to be ſo; as by other Reaſons, ſo eſpecially by the Eclipſes of the Moon: For an Eclipſe of the Moon has not in it ſelf any Diverſity of Time, being at one and the ſame Inſtant without reſpect of Places; yet becauſe in the Eaſtern Parts the Day is begun, and it may be far ſpent before it begins in Places far Weſterly, therefore ſuch an Eclipſe may appear to the Eaſtern Inhabitants towards the End of their Night, which to the Weſtern appears in the beginning or middle of the ſame Night with them: and ſo the Difference will be more or leſs, according to the different Diſtance of thoſe Places in Longitude.

Fourthly, Furthermore we ſee, that going or ſailing to the Northwards, we have the Artick Pole, and northern Star more elevated, and the Antartick Pole and Southern Star more depreſſed, the Elevation Northerly encreaſing equally with the Depreſſion Southerly, and either of them proportional to the Diſtances which we go: The like happens in going to the Southwards. Beſides the Oblique Aſcenſion, Decenſions, Occultations, Emerſions, and Amplitudes of riſing and ſetting of the Sun and Stars in every ſeveral Latitude, agreeable to the Hypotheſis of the Earth's Sphericity. All which could not be ſo, if the Earth were of any other than of a Spherical Form.

Fifthly, So if we ſtand upon the Sea-ſhore, and ſee a Ship far off under Sail making towards the Land, at firſt we ſee only the Top-Sails or higheſt Parts, and withal do manifeſtly behold the Convex Superficies of the Sea, as it were raiſed and interpoſing it ſelf between our Sight and the Hull, or lower Parts of the Ship, till ſhe approaches nearer, and this uniformly e'ry way alike, and proportionably to the ſeveral diſt. which does evidently demonſtrate the Spherical Roundneſs thereof.

Sixthly and Laſtly, (to add no more) The Navigations of theſe latter Times make it apparent, thoſe eſpecially that have been made round about the World, as thoſe two Voyages by our famous Country-men Sir *Francis Drake*, and Mr. *Thomas Candiſh*, both which ſeverally ſailing from our Coaſt to the *Weſt-Indies*, and paſſing the Straights of *Magellane*, continued their Courſe Weſterly, till they came into thoſe Parts which are from us to the Eaſtward, namely, to the *Eaſt-Indies*, and ſo ſailed ſtill Weſterly till they came to *Cape Bon Eſperance*, and thence returned into *England*: Having ſailed about the whole Terreſtial Globe

Globe, they found nothing by their Obſervations or Reckonings different from the uniform Sphericity thereof in all its Parts. That they came ſhort in the Number of the Days, one, or reckoned the Time of their Abſcence leſs by one Day and Night than they which remained at Home, this farther confirms the thing in hand.

Yet whilſt we ſpeak here of the Roundneſs of Earth and Sea, we intend it not ſo ſtrictly, as if it were a thing turned round without any inequality to its Superfices; but as a Bowl or Ball, though it hath ſome Duſt or ſmall Grains of Sand cleaving thereto, may ſtill be ſaid to be round. So though the Land, Hills, and Mountains be ſomewhat raiſed above the Spherical Superficies of the Sea, and if there ſhould be alſo ſome Valleys or Bottoms more depreſſed; yet ſeeing the greateſt of theſe Innequalities, have ſcarce any ſenſible Proportion to the Whole, we may well affirm the Whole to be round.

The Relations made of the prodigious Height of ſome Mountains, as to be 60 or 70 Miles high, if it be underſtood of their perpendicular or direct Height, are fabulous. The Mount *Atlas* is recorded by ſome of the Antients, to reach up almoſt to the Moon, and to be as it were a Pillar for the Heavens to reſt upon, being meaſured Geometrically by *Eratoſthenes*, the Perpendicular or upright Height from the Top thereof to the Valleys beneath, was found not to exceed 10 *Stadiums*, which of our *Engliſh* Meaſure is little more than a Mile and a Quarter, a *Stadium* not much differing from our Furlong, and the like might be ſhewed of others. But if we admit the higheſt Mountain to riſe Perpendicular above the Spherical Superficies of the Sea two Miles, yet ſeeing the Diameter or whole Thickneſs of the Earth, is, as we have before ſhewed, 7966 Miles, this Exorbitancy or Difference of two Miles is of ſmall Moment; yea, if there were any Mountains eight Miles in Height upright, yet this compared with the whole Thickneſs of the Earth, is little more than one thouſandth part thereof; therefore we may conclude that this Terreſtrial Globe, conſiſting of the Earth and Sea, is Spherical. We come in the next Place to ſhew, by what way of meaſuring we found the Parallel of *York* to be diſtant from the Barallel of *London* 9149 Chains. And ſo how the Diſtance of the Parallels of two Places may be exactly meaſured.

Chap. III. *A moſt exact Way for finding the Quantity of the Diameter and Circumference of the Earth and Sea, and of a Degree on the ſame.*

I Do the more fully ſet down the Way of making this Experiment, that ſo I may give an Occaſion to any who are ſo nobly minded for a publick Good, as to be at that Charge, to make a farther and more exact Trial thereof. Now then the beſt and perfecteſt Way is, to obſerve ſo exactly as may be, the Summer Solſtitial Altitudes of the Sun at two places ſo far diſtant aſunder, and lying ſo near North and South, each from the other, with ſo direct and fair a Way betwixt them as conveniently may be choſen: Suppoſe for Example, *Chriſt-Church* and *Berwick*, or ſome other Place in the fartheſt part of *Scotland*; for the further theſe two Places are each from other, the more perfectly may this Buſineſs be performed. Then meaſure as truly as is poſſible, and ſet down in a Book all the Way between thoſe two Places, with all the Windings, Aſcents and Deſcents that are therein, whereby with the Help of the enſuing Table, you may eaſily and exactly find how much the one Place is more Southerly than the other. For

this Purpose, the plain Table is not the fittest Instrument, but rather a *Theodelite*, or *Peractor*, or some other of that kind, observing diligently the Variation of the Needle. The Chain may be 6 Poles long, or rather 100 Feet, and the Table fitted accordingly (but the Table following is for Poles) if it should be much longer, it would be too heavy. The high-ways are commonly crooked; yet because of sundry Obstacles and Impediments which are incident out of the Way, and because a Man cannot certainly at first direct himself the neareſt and best Way to the Place intended, it would be expedient to measure the distance as aforesaid; first in the High-ways leading from the one to the other, and then in the neareſt and best Way that could be chosen between them; and so if any notable Error happen in the one, it may be discovered and amended in the other. The Form of which I observed in setting down the Measures and Angles was according to this Examp.

	Deg.	*Distances.*	*North.*	*South.*	*East.*	*West.*	
	S. E. 31						
	S E. 20						
	S E. 13						
	S E. 13						
	S W. 2						
	S E. 5						

It is to be understood that the Table here following, was before calculated to serve instead of a *Peractor* or *Circumventor*, or other graduated Instrument, and for a Chain of 3 Poles, which for the most part I use, yet it may be very well applied to a Chain of 6 Poles (as in this Business it was) reckoning every Chain to be two, &c. And thus for every 10 Chains, of 6 Poles to a Chain, I make 2 Stroaks, signifying 2 Changes or 20 Chains, and if there be any odd Chains, for those I set a figure in another Line next below; and if moreover any odd Poles, whether one or two, for those I set another Figure in a third Line below. Thus the last Entrance before-going, being SE. 5 Degrees, signifies that the Line upon which I went, was from the South part of the Meridian to the Eastwards, making an Angle with the Meridian of 5 deg. the 9 Stroaks signify 9 Changes or 90 Chains, the Figure 5 signifies 5 Chains, and the Figure 2 two Poles. So that it is to be read thus, South-easterly 5 Deg. 9 Changes, 5 Chains, and 2 Poles, and the like is to be understood of the rest. But for the most part, having liberty of Ground, I end the measure off every Line, either with a whole Number of Changes, or at least of Chains.

And thus proceeding all Day, towards the Evening, or when else I have time convenient, I reduce all these Distances upon what Lines or Angles soever they be to Distances of North or South, East or West, as here appears. Deg.

	Deg.	Distances	North.	South	East.	West.	
	SE. 31			2571	1545		
	S. E. 20			2819	1026		
				1692	616		
	SE. 13			0169	062		
				2923	675		
	SE. 13			1754	404		
	SW. .2			1499		052	
	SE. .5			2690	235		
				0149	013		
				0020	002		
	Chains.	571		16286	4578	052	
		1		0	52		
	Poles.	1715		16286	4526		

We will explain the last, and so the rest may be easily understood; South East 5 degrees, 5 2. Here because I have SE. the Numbers taken out of the Table must be put in the Columns intituled *South* and *East*. Then in the Table under 5 deg. I look for 9 Changes, and find against it 2690, and in the adjacent Column under the Complement thereof 235: and because SE. 5 deg. is less than 45 deg. that is nearer the South than the E. I put it into the Column entituled *South* 2690, and in that entituled *East* 235; then again in the same Tabular Column under 5 deg. I find against 5 Chains (cutting off a Figure, because 5 Chains is but the tenth part of 5 Changes 149, to be put in the S. Column, and 13 for the E. Column. Lastly, against 2 Poles, I find for the S. Column 20, and for the E. 2: and the like is to be understood of all the rest. Now supposing this last to be a place, whose Distance and Situation from the first is required; I sum up the Columns severally, and of the North and S. Columns, subtract the lesser from the greater, and so of the E. and W. Columns; and so it will appear how much N. or S. and how much E. or W. the last place is from the first.

As in this *Examp.* we find the last place to be to the S. ward of the first 1628 Poles, for the last Fig. may be cut off, being used in the Table only for the more exactness, or may be made a Fraction, and so it is 1628, $\frac{6}{10}$ Poles: Likewise the last place is to the E. wards of the first 452, $\frac{6}{10}$ Poles: and thus I proceed all the way. Now touching the Angles of Ascent and Descent of Hills and Valleys; to have observed them exactly, would have required more Time and Charge than I could of my self bestow, yet I made Allowance for such of them as were of most Moment: He that would observe them all, may either make 2 or 3 Col. more, or keep an Account of them a part by themselves. But if he intend no farther Use of them, but to find the nearest Dist. he need not set them down but make allowance for them on the Ground, keeping his Dist. entire without Fractions. As admit I observe the Ascent from a Valley to the Brow of a Hill to be 14d. above the Level or Horizontal Line, and that measuring I find the Distance to be 30 poles: I turn to the Table, and under 14d and against 10 Chains I find 2911, and 726, shewing that the Level or Horizontal Distance from my Station to that Brow is only 29, $\frac{1}{10}$ poles, and that the height of that Brow above the level Line is but 7, $\frac{26}{100}$ poles: but finding thus that the Hypothenusal being 30, the Base or level Line is but 29, $\frac{1}{10}$, that is, less by $\frac{89}{100}$, because I would avoid this Fraction, I add to the end of the foresaid measure of 30 poles upon the level Line, $\frac{89}{100}$ of a pole, and then I may account my self distant from the place in the Valley 30 poles in a level or Horizontal Line, and so set down the Distance without a Fraction: The like is to be understood of all other Ascents and Descents. *Here*

Here follows the TABLE.

	1*d*	89*d*	2*d*	88*d*	3*d*	87*d*	4*d*	86*d*	5*d*	85*d*
1	300	5	300	10	300	15	299	21	299	26
2	600	10	600	21	600	31	599	42	598	52
3	900	15	900	31	899	46	898	63	896	79
4	1200	20	1200	42	1198	62	1198	84	1195	105
5	1500	26	1500	53	1498	78	1497	105	1494	131
6	1800	31	1799	64	1798	93	1796	126	1794	157
7	2100	37	2099	74	2097	110	2095	147	2093	183
8	2400	42	2398	84	2397	124	2394	168	2391	209
9	2700	47	2698	95	2696	140	2694	189	2690	235
10	3000	52	2998	105	2996	157	2993	210	2989	260
1	10	00	10	0	10	0	10	1	10	1
2	20	00	20	1	20	1	20	1	20	2

	6*d*	84*d*	7*d*	83*d*	8*d*	82*d*	9*d*	81*d*	10*d*	80*d*
1	298	31	298	37	297	42	296	47	295	52
2	597	62	596	74	594	84	592	94	590	104
3	895	94	894	111	891	125	889	140	887	156
4	1193	126	1192	146	1188	167	1185	187	1182	208
5	1492	157	1489	183	1485	209	1481	234	1477	260
6	1790	188	1787	220	1782	251	1777	281	1772	312
7	2089	220	2085	257	2080	292	2074	328	2069	365
8	2386	251	2383	292	2377	334	2371	375	2364	417
9	2686	282	2680	329	2674	376	2666	422	2659	469
10	2984	314	2978	366	2971	418	2963	469	2954	512
1	10	1	10	1	10	1	10	1	10	1
2	20	2	20	2	20	3	20	3	20	3

	11*d*	79*d*	12*d*	78*d*	13*d*	77*d*	14*d*	76*d*	15*d*	75*d*
1	295	57	293	62	292	67	291	73	290	78
2	590	114	586	124	584	134	582	146	580	156
3	883	172	881	188	876	203	873	219	870	233
4	1178	229	1174	250	1169	270	1164	290	1160	310
5	1473	286	1467	312	1461	337	1455	363	1449	388
6	1768	343	1760	374	1754	404	1746	436	1739	466
7	2060	401	2055	436	2047	472	2038	508	2030	543
8	2355	458	2348	500	2339	540	2329	580	2320	621
9	2650	515	2641	562	2631	608	2620	653	2610	699
10	2945	572	2934	524	2929	675	2911	726	2898	776
1	10	2	10	2	10	2	10	2	10	3
2	19	4	19	4	19	4	19	4	19	5

	16d	74d	17d	73d	18d.	72d.	19d	71d.	20d	70d.
1	288	83	287	88	285	93	284	98	282	103
2	576	166	574	177	570	186	568	196	564	206
3	865	250	861	264	855	279	851	294	846	308
4	1153	332	1148	352	1140	371	1135	391	1128	411
5	1442	413	1434	438	1426	463	1418	488	1410	513
6	1730	496	1721	526	1711	556	1702	586	1691	616
7	2019	580	2008	615	1997	649	1986	684	1973	719
8	2307	663	2296	703	2282	743	2270	782	2255	821
9	2596	746	2583	791	2567	836	2552	880	2537	924
10	2884	827	2869	877	2853	927	2836	977	2819	1026
1	16	3	10	3	10	3	10	3	10	3
2	20	5	19	6	19	6	19	6	19	6

	21d.	69d	22d.	68d.	23d.	67d.	24d.	66d	25d.	65d
1	280	107	278	112	276	117	274	122	272	127
2	560	215	556	224	552	234	548	244	544	254
3	840	322	834	337	828	351	822	366	816	381
4	1120	429	1112	449	1104	468	1096	488	1088	508
5	1400	537	1391	562	1380	586	1370	610	1360	634
6	1680	645	1669	674	1656	703	1644	732	1632	761
7	1960	752	1947	786	1932	820	1918	854	1904	888
8	2240	860	2225	899	2209	937	2192	976	2175	1015
9	2521	968	2504	1011	2485	1054	2460	1098	2447	1142
10	2801	1075	2782	1124	2761	1172	2740	1220	2719	1268
1	9	4	9	4	9	4	9	4	9	4
2	18	7	18	8	18	8	18	8	18	8

	26d.	64d.	27d.	63d.	28d.	62d.	29d.	61d.	30d.	60d.
1	270	131	267	136	265	141	262	145	260	150
2	540	263	534	272	530	282	524	290	520	300
3	810	394	801	408	795	423	786	435	780	450
4	1079	525	1068	544	1060	564	1048	581	1040	600
5	1348	657	1336	681	1324	704	1312	727	1299	750
6	1618	788	1603	817	1589	845	1574	872	1559	900
7	1888	919	1870	953	1855	986	1836	1017	1819	1050
8	2157	1050	2138	1089	2120	1127	2098	1162	2079	1200
9	2427	1182	2405	1225	2384	1267	2361	1308	2339	1350
10	2696	1315	2673	1362	2649	1408	2624	1454	2598	1500
1	9	4	9	5	9	5	9	5	9	5
2	18	8	18	10	18	10	18	10	18	10

	31d	55d	32d	58d	33d.	57d.	34d.	56d.	35d.	55d.
1	257	154	254	159	252	163	249	168	246	172
2	514	309	508	318	504	326	498	336	492	344
3	773	463	763	477	755	489	747	504	738	516
4	1028	617	1017	636	1007	653	995	671	983	688
5	1285	772	1272	795	1258	817	1243	838	1228	860
6	1542	927	1526	955	1510	980	149	1006	1474	1032
7	1809	1081	1780	1113	1762	1143	1741	1174	1720	1204
8	2057	1235	2034	1272	2013	1307	1990	1342	1966	1377
9	2314	1390	2288	1431	2265	1470	2238	1510	2212	1549
10	2571	1545	2544	1590	2516	1634	2487	1677	2457	1721
1	9	5	8	5	8	5	8	6	8	6
2	18	10	16	10	16	10	16	12	15	12

	36d.	54d.	37d.	53d,	38d.	52d.	39d.	51d.	40d.	50d.
1	243	176	240	180	236	185	233	189	230	193
2	486	352	480	360	472	370	466	378	460	386
3	729	528	720	541	709	555	699	567	690	578
4	971	705	960	721	945	739	932	756	920	771
5	1213	881	1198	902	1182	923	1165	944	1149	964
6	1456	1057	1438	1082	1418	1108	1398	1133	1379	1157
7	1699	1234	1678	1262	1654	1293	1631	1322	1609	1350
8	1942	1410	1918	1443	1890	1479	1865	1511	1839	1543
9	2185	1586	2157	1624	2126	1663	2098	1700	2069	1735
10	2427	1763	2396	1805	2364	1847	2331	1888	2298	1928
1	8	6	8	6	8	6	8	6	8	6
2	16	12	16	12	16	12	16	12	16	12

	41d.	49d.	42d.	48d.	43d.	47d.	44d.	46d.	45d.	45d.
1	226	197	223	201	219	205	216	208	212	212
2	452	394	446	402	438	410	432	416	424	424
3	678	591	669	603	658	614	648	625	636	636
4	905	788	892	803	878	819	864	833	849	849
5	1132	984	1114	1003	1097	1023	1079	1042	1061	1061
6	1358	1181	1337	1204	1316	1228	1295	1250	1273	1273
7	1584	1378	1560	1406	1535	1433	1511	1458	1485	1485
8	1810	1575	1783	1607	1754	1638	1727	1666	1697	1697
9	2036	1772	2006	2807	1974	1842	1943	1874	1910	1910
10	2264	1968	2229	2097	2194	2046	2158	2084	2122	2122
1	8	7	7	7	7	7	7	7	7	7
2	16	14	14	14	14	14	14	14	14	14

The Structure of this Table is from this Ground

As Radius is in Proportion to the Diſtance of the two Places meaſured in their Rhomb, ſo is the Sine of the Complement of that Rhomb, to the Difference of the Latitude of the two Places.

And ſo is the Sine of that Rhomb, to the diſtance of the Meridians of thoſe two places.

As admit I meaſure South Eaſterly 20d. 300 Poles, here then the Rhomb upon which I meaſure, making with the Meridian an Angle of 20d. I ſay,

As Radius is in proportion

To the diſtance meaſured, 300 Poles ——— 2.47712.

So is the Sine of the Complement of the Rhomb S E. 20 deg. ——— 9.97299.

To the difference of Latitude 281 $\frac{9}{100}$ *fere* ——— 2.45011

Whereby it appears, that the diſtance of the Parallels of theſe two Places is 281, $\frac{21}{100}$ Poles, or that the Place whereto I meaſure is more Southerly than the Places from whence I meaſured, by 281, $\frac{21}{100}$ Poles

Now for the diſtance of their Meridians, ſay,

As Radius is in proportion

To the diſtance meaſured 300 Poles ——— 2.47712.

So is the Sine of the Rhomb South Eaſt 20 deg. ——— 0.53405.

To their difference of Longitude 102 $\frac{6}{100}$ ——— 2.01117

Ch.	*Poles*
1	28.19
2	56.38
3	84.57
4	112.76
5	140.95
6	169.14
7	197.33
8	225.52
9	253.71
10	281.92

And thus I find the Place whereunto I meaſured, is more Eaſterly than the place from which I meaſured, by 102$\frac{6}{100}$ Poles and ſomewhat more, and in like ſort may be found all the other Numbers expreſſed in this Table; but having thus found for every deg. to 45 deg. two Numbers, the reſt may be deduced from, as in this Example 300 Poles, at 3 Poles to the Chain, is 100 Chains, or 10 Changes: finding that in 10 Changes upon this Degree, the difference Southerly is 281$\frac{9}{100}$ Poles, it muſt be for 5 Changes, which is juſt half ſo much by almoſt 141; and for one Change which is a tenth part, 28 $\frac{3}{100}$ *fere*, and ſo for 2 Changes twice ſo much, that is, 56$\frac{4}{100}$, for 3 Changes thrice ſo much, that is, the Sum of the two former namely 84$\frac{6}{100}$, and ſo by Addition only you may find the reſt, as in this Table, which I ſhall need to proſecute no further. And thus you may take it to the hundred or thouſand parts of a Pole; but this for ordinary occaſions, for which it was firſt intended, may ſuffice. And according to this Example, it will be eaſy to frame the like Table for a Chain of any other Size, or for any other Meaſure which you uſe.

It may be objected, that howſoever this Rule holds true in plain Triangles yet the Triangles here uſed are neither plain nor ſpherical, for a plain Triangle is made of three right Lines, a ſpherical of three Arches of great Circles, but in this, the three ſides are of three ſeveral kinds, namely, one ſide is an Arch of the Meridian, and ſo of a great Circle, another an Arch of a parallel, and ſo of a leſſer Circle, the third ſide or *Hypothenuſal* being the Rhomb is no Arch of a Circle, but a Segment of an *Heliſpherical* Line. But I anſwer, That notwithſtanding this may be ſpeculatively conceived, and ſo be demonſtrated to be no plain Triangle; yet in ſo ſmall diſtances as theſe which here we uſe, there can be no ſenſible, nor ſcarce any numerable difference. Yea, the diſtance between two parallels by the Rhomb and diſtance given (being the thing here chiefly aim'd at) is very exactly found by this Rule, as before we have ſhewed, and more fully by Mr. *Wright*, in

in his *Corection of Errors in Navigation.* Whence we may conclude that the parts of the Meridian collected by this Table according to the Rhombs and Diſtances, as before we have ſhewed do give the Meaſure of the Segment of that Meridian intercepted between the Parallels of the two Places propoſed

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CHAP. IV. *Of the Difference of Longitude, Poſition, and Diſtance of* York *and* London, *And how the Maps of* England *may by this Experiment be reformed, eſpecially in the Latitude of Places.*

WE come next to ſpeak of the Eaſterly and Weſterly Diſtances, gathered as before is ſhewed by theſe Tables, and to find thereby the Difference of Longitude: and of this we will give an Example in the aforeſaid Experiment: Whereby we find that the Difference of Longitude, or the Eaſt and Weſt Diſtance between *York* and *London*, is near 14000 Poles. *London* being ſo much more Eaſterly than *York*. And before we have found that in a Degree of the Meridian, and conſequently in a degree of the Equinoctial, there is near $3709\frac{1}{10}$ Chains, at 6 Poles to the Chain, and theſe 14000 Poles converted into ſuch Chains, are $2333\frac{1}{3}$.

Which $2333\frac{1}{3}$ Chains for finding the difference of Longitude, are not to be reckoned in the Parallel of *York*, that being too much Northerly; neither in the Parallel of *London*, being too much Southerly, but in a middle Parallel between both; namely, about the Latitude of 52 deg. 45 min. Now to find what difference of Longitude is anſwerable to this $2333\frac{1}{3}$ Chains in the Parallel of 52 deg. 45 min. Say,

As Radius is in Proportion
To the Sine Complement the Latitude 52 deg. 45 min. ——— 9.78197
So is the Meaſure of a degree in the Equinoctial $3709\frac{1}{10}$ ——— 3 56927
To the Meaſure of a degree in that Parallel $2245\frac{1}{10}$ ——— 3 35124

And thus we find that in the Parallel, whoſe Latitude is 52 deg. 45 min. there are $2245\frac{1}{10}$ Chains anſwering to a degree, whereby it appears that the difference of Longitude between *York* and *London* is more than one degree. And to find how much more, ſay again by the Rule of Proportion

As the Meaſure of a degree $2245\frac{1}{10}$ ——— *Co. Ar.* ——— 6.64876
Is to a degree in ſeconds, 3600 ——— 3 55630
So is the Meaſure given, $2333\frac{1}{3}$ ——— 3.36797
To the Number of ſeconds, 3741 ——— 3.57303

Which reduced is 1 deg. 2 min. 21 ſecond. And thus we find that *London* doth differ in Longitude from *York* 1 deg. 2 min. 21 ſeconds, being ſo much more Eaſterly.

Thus having the difference of Latitude as alſo the difference of Longitude between theſe two Places, we may (according to the ſecond Problem of ſailing by *Mercator's*-Chart) find the Rhomb from *London* to *York* to be 14 deg. 20 min. from the North to the Weſtward; that is, North and by Weſt, 3 deg. 5 min. Weſterly, and the diſtance in that Rhomb 9442 Chains. But their diſtance in the Highway, by reaſon of the crookedneſs and unevenneſs of it, was more by about an eighth part; And the like might be done for other intermediate Places between theſe, but affecting Brevity, we paſs that over, as not much pertinent to our preſent purpoſe.

Chap. VI. *Of dividing the* Log-Line, *and reckoning the Ship's Way.*

THERE be four things upon which the Practice of Navigation especially is grounded, namely, the knowledge of the Longitude, Latitude, Course and Distance. Touching the Longitude tho' it may be found by the other three, yet hitherto there hath not been delivered any general Rule, true and practicable, whereby the Longitude of Places might be immediately and ordinarily found of themselves The Latitude of Places might be immediately found by Observation of the Sun and Stars, as we have formerly shewn in the Appendix to the *Doctrine of Triangles:* The Course by the Compass, the Variation being duly observed, wherein we have many good Mariners very expert; this we have also handled in the *Doctrine of Spherical Triangles.* The Distance run, is found of it's self by the *Log-line*, whereof we are here to speak.

The ground of finding the Distance run by the *Log-line*, is merely conjectural, being founded upon this Opinion, that 5 of our Feet make a Pace, and 1000 such Paces make a Mile, and that 60 such Miles make a Degree; so that a Degree should contain 300000 of our Feet. But it appears not only by this Experiment, but even by all others that were diligently taken, and their Measures to us known, that there is a greater number of our Feet contained in a Degree.

There be three things (as I conceive) that have caused this Error to be so commonly received and tolerated. The one for that it does somewhat counterpoise another contrary Error in the practice of Navigation, namely, in the Use of the *Plain Chart*; for the Error which is there committed by making every Parallel equal to the Equinoctial, and so every Degree in them greater than they should be, is something moderated by this Error; whereby the measure of a Degree is esteemed less than indeed it is. For Instance; it is evident by the Globe, that the Meiridan, concurring in the Poles grow nearer and nearer together, as they grow towards the Pole, insomuch as if two Meridians be distant in the Equinoctial 10 Degrees, that is 600 Miles, the same Meridians in the Latitude of 35d. will be distant little more than 490 Miles. Now if unto every Mile we account according to the former Experiment 6120 Feet, then is the distance of those two Meridians in that Parallel near 3000000 Feet. In like sort in the *Plain-Chart* 1od. of that Parallel (as of all others) is made equal to 10 deg of the Equinoctial or Meridian; so that the Distance of those two Meridians will upon the *Plain-Chart* be 600 Miles, but one of these Miles contain only 5000 Feet, so that the Distance is but 3000000 Feet equal to the former. And although these Errors in other Cases do not justly ballance one another, as in this Example, yet that of the *Plain-Chart* is always something moderated by this order, and so much the more, by how much they are nearer to the foresaid Latitude I grant that this is only so when the Course is near unto the E. or W. Points; but withal I say, that this kind of Reckoning is (in a manner) then only used: For he that runs any Course near the Meridian S.erly or N.erly, hath a more certain way of Reckoning, namely, his Latitude, which he finds daily by Observation of the Sun and Stars, upon which he will depend, either neglecting, or at least not regarding his Dead Reckoning. Yea, it may be never casting the *Log.* so much as once in such a Voyage, having a more sure ground for his Reckoning But in a Course that is near E. and W. forasmuch as there is no way discovered for finding the Long. he is driven of necessity to make Use of his Dead Reckoning.

We might add moreover, that the principal Voyages of this kind, I mean of those which consists of Courses much Easterly and Westerly, as to and from the *West-Indies*, and the Parallel of Cape *Bon Esperance*, are near unto this Latitude of 39 deg so that as some of them are more Southerly, others of them are more Northerly.

But to insist no longer upon this, I suppose a second Cause to be, for that Men commonly desire to have their Reckonings before their Ship as they say, that they fall

not with a Place before they look for it: And this comes so to pass, whilst the Miles are accounted less in Measure, and so more in number than they are indeed

And thus, though there may seem to be some Commodity in these Errors, especially when they do nearly ballance one another; yet because they seldom do so, but always leave Men in Uncertainties, and oftentimes in great Perplexity and Danger, it is much safer and better to reject them both, and to imbrace those Ways which are evidently grounded upon Truth, though there may be in them some more Difficutly at the first. Yet I confess, that which reforms one and not another, may sometimes err so much the more thereby. And I doubt not, but many would reform them both, if they could certainly do so

Therefore a third Cause of admitting and retaining this Error seems to be, for that there hath no Way been delivered from evident and certain Grounds for the rectifying of it I doubt not but many have found Errors in their Reckonings, arising from hence, that they account only 300000 of our Feet to a Degree; but not knowing certainly where to lay the Fault, have imputed it sometimes to ill Steerage, otherwiles to the Variation of the Needle, or to some Mistake in their Reckonings, or to some Error in their Plots, or to some Currant, or such other Accident, and so the Error hath rested unreformed Wherefore, although the practical Performance of this Problem, for finding the Circumference of the Earth, or the Quantity of a Degree on the same, have many singular Uses, which I cannot now touch; yet that which among the rest I chiefly aim'd at, was that we might have a more sure and evident Ground for dividing the *Log-line*, and for Reckoning the Ship's Way or Distance run more truly upon any Rhomb or Point of the Compass than formerly. And now to apply it to this Purpose; we have noted before (*Chap.* 2) that by the Experiment there expressed, we find in a Degree on the Circumference of the Earth and Sea, 367200 of our English Feet, wherefore retaining still the same Division of a Degree, into 60 Miles, or 20 Leagues, (as hath been formerly used) a Mile will contain 6120 Feet, or 1020 Fathom: and so a League contains 10360 Feet, or 3060 Fathom; for dividing 367200 by 60, the Quotient is 6120, *&c.* Thus then 60 Miles being a Degree, every Mile is 6120 Feet.

Now supposing the time of the running out of the *Log-line*, to be Measured by a Half-Minute Glass, if we observe how many Feet or Fathom she runs in half a Minute, we may thereby find her Way for an Hour, or 4 Hours, or for any other time proposed.

As admit there runs out of the *Log-line* in half a Minute's space 51 Feet, or 8 $\frac{1}{2}$ Fathoms, and you would know what way the Ship makes every Hour after the same Rate; say by the Rule of Proportion.

If half a Minute gives 51 Feet, what gives 60 Minutes? Or,

If 1 Minute gives 102 Feet, what gives 60 Minutes?

And so multiplying, you shall find 6120 Feet, which is one Mile. Or, if you would find her way for 4 Hours, which is 240 Minutes, say,

As 1 Minute is in Proportion to 240 Minutes;

So are 102 Feet to 24480 Feet, or 4 Miles.

Or if you would have it in Fathoms; say,

As 1 Minute is in Proportion to 240 Minutes,

So is 17 Fathoms to 4080 Fathoms, the Ship's way in 4 Hours.

The like is to be conceived, if your Glass be for any other Quantity of Time above or under half a Minute.

Some have thought that the way which the Ship maketh, may be known to an old Seaman, by Experience (as they say) that is, by Conjecture, which Opinion makes some neglect the Use of the *Log* least they should be accounted young Seamen. But as he that rides often, will have some near Guess how far the pace he rides will carry him

him in an Hour (becauſe he hath often obſerved it formerly;) ſo he which hath often ſailed, and hath kept an Account of the Ship's way by the *Log* will be able to give ſome near Eſtimate of her way without the *Log*. But it is incident to ſome Men to have ſuch a Conceit of this their Eſtimate, that they think it more certain than the Rule it ſelf from whence it is derived, eſpecially if it chance to anſwer their Expectation at ſometimes It is thought alſo that the Ship's Way may be known by two Marks on the Ship's ſide. But this is doubtleſs very uncertain, both by reaſon of the Shortneſs of the Time, and in reſpect of the dead Water (as they call it) by the Ship's ſide. For the Water which is near the Ship is drawn along with the Ship in her Motion, and ſo much the more, by how much it is nearer

But if any deſire to make Trial of this way, it is to be conſidered, that 17 Foot is $\frac{1}{320}$ part of a Mile, and 10 ſec. of a Minute is $\frac{1}{360}$ part of an Hour; Therefore if there be two Marks on the Ship's ſide, diſtant 17 Feet, if the Ship run the diſtance of theſe two Marks in 10 ſec. ſhe runs a Mile in an Hour, if in 5 ſec two Miles an Hour, if ſhe runs that diſtance in 2 ſec ſhe runs 5 Miles in an Hour. And ſo always dividing 10 ſec by the number of ſec. in which the Ship runs that Diſtance, the Quotient ſhews the Miles and parts of a Mile run in an Hour.

But if the Diſtance of thoſe two Marks be 34 Feet, if ſhe runs it in 20 ſec. it is after a Mile an Hour; if in 10 ſec two Miles an Hour; if in 5 ſec. 4 Miles an Hour; and ſo always dividing 20 ſec by the number of ſeconds in which the Ship runs that Diſtance, the Quotient ſhews how many Miles the Ship runs in an Hour. As if the Ship run that Diſtance of 34 Feet in 8 ſec. then dividing 20 by 8, the Quotient is $2\frac{1}{2}$, ſhewing that ſhe runs $2\frac{1}{2}$ Miles in an Hour. Or if you can conveniently make the Diſtance of the two Marks on the Ship's Side to be 51 Feet (for the further they are diſtant the better) then if the Ship run that Diſtance in 30 ſec. it is a Mile an Hour, if in 10 ſec. it is 3 Miles an Hour, and ſo always dividing 30 ſec. by the number of ſeconds, in which the Ship is running that Diſtance the Quotient ſhews after that rate how many Miles the Ship runs in an Hour. Otherwiſe you may do thus: Divide 17 Feet into 10 Parts, and ſet as many of thoſe parts on the Ship's ſide as conveniently you may, which according to the Ship's length will be more or fewer. Then when the Ship runs one of thoſe Parts in a ſecond of Time, it is a Mile an Hour; when two, it is two Miles an Hour; when five it is five Miles an Hour. And in general, if you divide the number of Parts run, by the Time of running accounted in ſeconds, the Quotient ſhews what number of Miles after that rate are run in an Hour. As if ſhe run 30 of thoſe parts in five ſeconds, it is ſix Miles an Hour; for dividing 30 by 5, the Quotient is 6; ſo if ſhe run 42 of thoſe parts in 10 ſeconds, dividing 42 by 10, the Quotient is $4\frac{2}{10}$, which ſhews the Ship's way at that time to be after the rate of 4 Miles and two tenths of a Mile in an Hour.

But for keeping this account of Time, it may be done either by a Sand-glaſs for that purpoſe, or by pronouncing certain Words or Numbers: As the Time wherein a Man, tells twice 60, pronouncing every Number as faſt as he can conveniently and diſtinctly, is about a Minute; ſo that the time wherein a Man is numbring 60, is half a Minute or 30 ſeconds; and whilſt a Man is numbring two (as one and twenty, two and twenty) is a ſecond, and ſo whilſt a Man is numbring from twenty to thirty is five ſeconds, from twenty to forty, ten ſeconds, &c. But in numbring from one to twenty, you may obſerve the ſame times as in numbring from one and twenty to forty, and this will not be hard to do; for whilſt a Man pronounceth one and twenty, two and twenty, three and twenty, &c there remains a certain Impreſſion in the Fantaſy whereby a Man is able in the ſame time to pronounce one, two, three, &c. And

although this Rule of numbring twice 60 for a Minute's ſpace, be not general to all Men, becauſe ſome are ſwifter or ſlower in the Pronunciation than others; yet after this Example, a Man making Trial, may frame a Rule to himſelf, whereby he may come ſomewhat nearer the Truth.

But leaving theſe, we come to the Diviſion of the *Log-line*, according to the half minute Glaſs, which is more uſual and certain: And conſidering, that half a minute is of an Hour $\frac{1}{120}$ part; therefore the Ship's Way running 51 Feet in half a minute is a mile an Hour; if ſhe runs twice ſo much, that is 102 Feet in half a minute, it is two miles an Hour, if thrice ſo much, it is three miles an Hour: And in general how many times 51 Feet ſhe runs in half a minute, ſo many miles is her way for an Hour. Therefore leaving half a ſcore Fathom, or more from the Log, that ſo it may be out of the Eddy of the Ship's Wake, before you begin to account or turn the Glaſs; if there you make a Mark for the beginning, and ſo 51 Feet, from thence a Mark of one Knot, and 51 Feet further a Mark of two Knots, and 51 Feet further (that is 153 Feet from your firſt Mark) another Mark of three Knots; and ſo proceeding, look how many Knots are veered out in half a minute, ſo many Miles is the Ship's Way for an Hour. Now for that which is veered out more above the juſt meaſure of a Knot or Knots, you may allow for every 5 Feet the tenth part of a Mile almoſt. As admit ſhe runs 5 Knots and 25 Feet in half a Minute; then is her Way according to $5\frac{5}{10}$ or 5 Miles and a half in an Hour; if 6 Knots and 10 Feet it is $6\frac{1}{10}$ Miles in an Hour, *&c.*

But according to the common Opinion of 5000 Feet to a Mile, and 60 ſuch Miles to a Degree, there ſhould be ſomething leſs than 7 Fathom, namely 41 $\frac{1}{3}$, Feet to a Knot.

And although he which veers the *Log-line* be careful to overhale it ſo ſlack, that it may not draw forward the Log, yet no (no doubt) it doth loſe ſome way, following the Ship a little as it is drawn by the Line, and withal by the Eddy of the Ship's Wake, and ſometimes alſo is caſt forwards by the Wind and Waves, when they come after the Ship: So that for theſe Cauſes, it is like there may ſometimes be allowed three or four Fathom more than is veered out; but this (as a thing mutable and uncertain) being ſometimes more, ſometimes leſs, cannot be brouught to any certain Rule, but ſuch Allowance may be made for it as a Man in his Experience and Deſcretion ſhall think fit.

If you would divide the *Log-line* ſo as it might give the Ship's way in Centeſms, or the hundredth part of a degree, and fit it to a half minute Glaſs; Then ſeeing the hundredth part of a Deg. is 3672 Feet, and the $\frac{1}{120}$ part thereof is $30\frac{3}{5}$ Feet; if you begin at the Mark at which you mean to turn the Glaſs; and meaſure from thence 30 Feet, and three fifth parts of a Foot, you may there place 1 Knot, and thence again meaſuring 30 Feet, and three fifth parts of a Foot, there place two Knots: and ſo proceeding at the end of every 30 Feet and three fifths, adding a Knot, the number of Knots which run out in half a Minute, is the number of Centeſms which the Ship runs in an Hour. As ſuppoſe there run out 10 Knots in half a minute, then the Ship's Way is according to 10 Centeſms of a De-

gree in an Hour, that is, the tenth part of a Degree, or 6 Miles. And ſo every three Foot above the juſt meaſure of Knots, is near the tenth part of a Centeſm, or the thouſandth part of a Degree. As if there run out of the *Log-line* 5 Knots and 12 Feet, then the Ship's way for an Hour is 5 Centeſms, and four tenth parts of a Centeſm, and the like is to be underſtood of others.

And after the Form of theſe Examples, you may divide the *Log-line* for any other quantity of Time, more or leſs than half a Minute, or for any other parts of a Degree propoſed.

Thus have we handled the Diviſion of the *Log-line*, according to the Meaſure before found of 367200 *Engliſh* Feet in a Degree. But becauſe (as I have before ſhewed) the Ship's way is commonly more than by the *Log-line* it appears to be, and every Man deſires to have his Reckoning ſomething before his Ship, that he fall not with a Place unexpected; for theſe and ſuch other Cauſes, and for the Rotundity of the Number, if any Man think it more ſafe and convenient in Sea-Reckonings, he may abate 1 in 51, and ſo aſſign to a Degree only 360000 Feet, and conſequently to a Mile 6000 Engliſh Feet.

And upon this Ground; if in half a Minute there run out 50 Feet of the *Log-line*, it is a Mile an Hour, and ſo if 100 Feet run out in a Minute.

For as 1 Min. is in Proportion to 60 Min. So is 100 Feet to 6000.

And ſo foraſmuch as 25 Feet is $\frac{1}{240}$ parts of a Mile, and 15 ſeconds is alſo $\frac{1}{240}$ part of an Hour: Therefore if there be two Marks on the Ship's ſide, diſtant 25 Feet, if the Ship run the Diſtance of theſe two Marks in 15 ſeconds, it is after the rate of a mile an Hour; if in 5 ſeconds, it is three Miles an Hour; and ſo always dividing 15 ſec. by the number of ſec. in which the Ship runs that Diſtance, the Quotient ſheweth the miles and parts of a mile run in an Hour. But if the Diſtance of theſe two Marks be 50 Foot, then if ſhe run it in 30 ſec. or half a min. it is a Mile an Hour, if in 10 ſec. 3 miles an Hour: if in 5 ſec. 6 miles an Hour (for 30 divided by 5, the Quotient is 6) And ſo always dividing 30 ſec. by the number of ſec. in which the Ship runs that Diſtance, the Quotient ſhews how many miles ſhe runs in an Hour, *&c.*

Otherwiſe if you make a Mark on the Ship's ſide at every 20 Inches, then when the Ship runs one of theſe parts in a ſecond of Time, it is a mile an Hour; when 5, it is 5 miles an Hour; if ſhe run 18 of theſe parts in three ſeconds, it is 6 miles an Hour: For dividing 18 by 3, the Quotient is 6. And in general, if you divide the number of the parts run by the number of ſeconds ſpent in running the Quotient ſhews the Ships way in miles for an Hour.

But for dividing the Log-line according to this ground of 6000 Feet in a Mile if you intend to uſe it with a Half-minute Glaſs, then becauſe half a Minute is $\frac{1}{120}$ part of an Hour, and 50 Feet is alſo the $\frac{1}{120}$ part of a Mile; therefore when the Ship runs 50 Feet in half a minute, her way is after the rate of a Mile an Hour, if 100 Feet in half a minute, it is two miles an Hour, *&c.*

Therefore half a ſcore Fathom or more from the Log, you may make a Mark, and beginning from thence, meaſure 50 Feet, and there make the firſt Knot, and

50

50 Feet farther two Knots, and 50 Feet farther three Knots: and ſo proceeding, look how many Knots are run out in half a Minute, and ſo many Miles is the Ship's way for an Hour; and every 5 Feet more beſides the Knots, is a tenth part of a Mile; and if there run out 6 Knots and 20 Feet in half a Minute, the Ship's way is after the rate of $6\frac{4}{10}$ Miles in an Hour, *&c.*

And ſo if the Glaſs were for any other time more or leſs than half a Minute, you make the Diſtance of your Knots proportional. As if it were for 20 ſeconds, then becauſe 20 ſeconds are of an Hour the $\frac{1}{180}$ part, I divide a Mile which is 6000 Feet by 180, and the Quotient is $33\frac{1}{3}$; therefore there muſt be a Knot at every 33 Feet and 4 Inches.

If your Glaſs be 36 Seconds, which is $\frac{1}{100}$ part of an Hour, divide 600 by 100, the Quotient is 60; ſhewing that there muſt be 60 Feet to every Knot; and then every ſix Foot over and above the Knots is a tenth part of a Mile more.

And ſo it is better that your Glaſs be more than half a Minute, rather than leſs; and the more the better, provided that there run out no more Line than you may hale in again, without danger of breaking.

Laſtly; if you would ſo divide the Log-line, that it might ſhew the Ship's Way in Centeſms of a Degree, and fit it to an Half-minute Glaſs: Then foraſmuch as the hundredth part of a Deg. is 3600 Feet, and the $\frac{1}{120}$ part thereof is 30 Feet; therefore beginning at the Mark whereat you intend to turn the Glaſs, meaſure from thence 30 Feet, and there make one Knot, and at 30 feet farther two Knots, *&c.* Then look how many Knots, run out in half a Minute, ſo many Centeſms of a Degree is the Ship's Way for an Hour. And ſo if the Glaſs be 36 ſeconds, then every Knot muſt have 36 Feet, *&c.*

Now if a Man ſailing between any two Places which lie near Eaſt and Weſt one from another, have kept his Reckoning by Courſe and Diſtance, uſing a *Log line* ſo divided, that it have a Knot at every 7 Fathom (as many do) and would reduce the Diſtance of thoſe two Places ſo found to their Diſtance in ſuch Miles, as theſe of 60 to a Degree, each containing as we have ſaid 6000 Feet; the Proportion in Number of thoſe to theſe, is as 6 to 5, for 6 of them makes 5 of theſe.

As admit a Man in his Dead Reckoning, uſing ſuch a *Log-line* as hath a Knot at every ſeven Fathom, and for every Knot running out in half a Minute, he accounts the Ship's Way to be ſo many Miles an Hour; and according to ſuch a Reckoning, ſuppoſe he finds the Diſtance of two Places to be 1224 Miles or 408 Leagues, and would know the Diſtance of the ſame Places in Miles of 6000 Feet to a Mile, which is according to a *Log-line* that hath a Knot at every 50 Feet,

Say then by the Rule of Proportion:

As the Number 6 ——— *Co. Ar.* ———	9.221841
Is in Proportion to 5; ———	0.698970
So is the Number given, 1224 ———	3.087781
To the Number of Miles required 1020 ———	3.008592

Which 1020 is the Diſtance of thoſe two Places in ſuch Miles whereof 60 make a Degree. Or to find the ſame in Leagues, the Proportion is: As 6 is to 5, ſo is 408 Leagues to 340 Legues.

And

And thus may the Distances of Places be found in such Miles, whereof 60 make a Degree, especially if with the Distance expressed in the *Plain Chart*, you compare the Reckonings of some skilful Mariners that have sailed from the one to the other. But thus to endeavour a Reformation of the *Plain Chart*, were a Labour to little Purpose; for there the Correcting of the true Situation of two Places, in respect of one another, is oftentimes an Occasion that the same Places are the more falsely situated in respect of others. Like as if there were two Places, 8 Miles distant, and it were required to place a third 3 Miles from either of them; here, if we set the third in the middle, it will be four Miles distant from either; But if attempting to mend the Error we mistake the third to be 3 Miles from the first, then it will be five Miles from the seocnd. And thus unavoidably the mending of the one is the marring of the other, because the thing proposed is not possible.

And such is the Error of the *Plain* or common *Sea-Chart*, representing the Earth and Sea, not as a Spherical, but as a Plain Superficies; not as if the Meridians did concur in the Poles, but as if they were always parallel one to another. So that the Graduation and Projection being such, the Situations and Distances of Places cannot be generally and truly expressed thereir.

But the Graduation and Projection of *Mercator's Chart*, agreeing without sensible Error with the Globe, there may in that be described all, or any Parts of the World, according to their Longitudes, Latitudes, Courses, and Distances, as truly, and far more conveniently for the Mariners Use, than by the Globe it self; and upon such a *Chart* so described, a Reckoning may be truly kept; and any Error committed, may easily be discerned and amended. Whereas on the *Plain-Chart*, if a Man find his Reckoning to disagree, he is so far from knowing how to amend it, that he can seldom conjecture where the Fault was.

The neglect and want of these Charts hath been, and is a great Imperfection in *Navigation* and *Geography*; for howsoever there be some which do daily set forth for Sale, Maps of the World, and of the Parts thereof, according to this Projection; yet to have them truly such, and fit for Navigation, requires in the Author or Maker of them good Knowledge, and some competent Ability of his own, or Aid from others, with a greater love to the Truth than to his own Profit; which may induce him to bestow such Industry, Time and Expence, as I have formerly noted to be requisite in such a Work.

Here follows a Table of the Northing, or Southing, Easting or Westing of every Degree from the Meridian, according to the Number of Miles run upon that Degree. Which for Brevity sake we call——

A TABLE of the Difference of Latitude *and* Departure *from the* Meridian.

1 Deg

Dist.	1 Deg. Lat.	Dep.
1	1.0	.0
2	2.0	.0
3	3.0	.0
4	4.0	.1
5	5.0	.1
6	6.0	.1
7	7.0	.1
8	8.0	.1
9	9.0	.2
10	10.0	.2
11	11.0	.2
12	12.0	.2
13	13.0	.2
14	14.0	.2
15	15.0	.3
16	16.0	.3
17	17.0	.3
18	18.0	.3
19	19.0	.3
20	20.0	.4
21	21.0	.4
22	22.0	.4
23	23.0	.4
24	24.0	.4
25	25.0	.4
26	26.0	.5
27	27.0	.5
28	28.0	.5
29	29.0	.5
30	30.0	.5
31	31.0	.5
32	32.0	.6
33	33.0	.6
34	34.0	.6
Dist.	Dep.	Lat.
	89 Deg	

Dist.	1 Deg Lat.	Dep
35	35.0	.6
36	36.0	.7
37	37.0	.7
38	38.0	.7
39	39.0	.7
40	40.0	.7
41	41.0	.7
42	42.0	.7
43	43.0	.8
44	44.0	.8
45	45.0	.8
46	46.0	.8
47	47.0	.8
48	48.0	.9
49	49.0	.9
50	50.0	.9
51	51.0	.9
52	52.0	.9
53	53.0	.9
54	54.0	1.0
55	55.0	1.0
56	56.0	1.0
57	57.0	1.0
58	58.0	1.0
59	59.0	1.0
60	60.0	1.1
61	61.0	1.1
62	62.0	1.1
63	63.0	1.1
64	64.0	1.1
65	65.0	1.2
66	66.0	1.2
67	67.0	1.2
68	68.0	1.2
Dist.	Dep	Lat.
	89 Deg	

Dist.	1 Deg. Lat.	Dep.
69	69.0	1.2
70	70.0	1.2
71	71.0	1.3
72	72.0	1.3
73	73.0	1.3
74	74.0	1.3
75	75.0	1.3
76	76.0	1.3
77	77.0	1.4
78	78.0	1.4
79	79.0	1.4
80	80.0	1.4
81	81.0	1.4
82	82.0	1.4
83	83.0	1.5
84	84.0	1.5
85	85.0	1.5
86	86.0	1.5
87	87.0	1.5
88	88.0	1.5
89	89.0	1.6
90	90.0	1.6
91	91.0	1.6
92	92.0	1.6
93	93.0	1.6
94	94.0	1.7
95	95.0	1.7
96	96.0	1.7
97	97.0	1.7
98	98.0	1.7
99	99.0	1.7
100	100.0	1.8
200	200.0	3.5
300	300.0	5.3
Dist.	Dep.	Lat.
	89 Deg	

Dist.	2 Deg. Lat.	Dep.
1	1.0	.0
2	2.0	.1
3	3.0	.1
4	4.0	.1
5	5.0	.2
6	6.0	.2
7	7.0	.2
8	8.0	.3
9	9.0	.3
10	10.0	.3
11	11.0	.4
12	12.0	.4
13	13.0	.4
14	14.0	.5
15	15.0	.5
16	16.0	.6
17	17.0	.6
18	18.0	.6
19	19.0	.7
20	20.0	.7
21	21.0	.7
22	22.0	.8
23	23.0	.8
24	24.0	.8
25	25.0	.9
26	26.0	.9
27	27.0	.9
28	28.0	1.0
29	29.0	1.0
30	30.0	1.0
31	31.0	1.1
32	32.0	1.1
33	33.0	1.1
34	34.0	1.2
Dist.	Dep	Lat

88 Deg.

Dist.	2 Deg. Lat.	Dep
35	35.0	1.2
36	36.0	1.3
37	37.0	1.3
38	38.0	1.3
39	39.0	1.4
40	40.0	1.4
41	41.0	1.4
42	42.0	1.5
43	43.0	1.5
44	44.0	1.5
45	45.0	1.6
46	46.0	1.6
47	47.0	1.6
48	48.0	1.7
49	49.0	1.7
50	50.0	1.7
51	51.0	1.8
52	52.0	1.8
53	53.0	1.8
54	54.0	1.9
55	55.0	1.9
56	56.0	1.9
57	57.0	2.0
58	58.0	2.0
59	59.0	2.0
60	60.0	2.1
61	61.0	2.1
62	62.0	2.2
63	63.0	2.2
64	64.0	2.2
65	65.0	2.3
66	66.0	2.3
67	67.0	2.3
68	68.0	2.4
Dist.	Dep	Lat.

88 Deg.

Dist.	2 Deg. Lat	Dep
69	69.0	2.4
70	70.0	2.4
71	71.0	2.5
72	72.0	2.5
73	73.0	2.5
74	74.0	2.6
75	75.0	2.6
76	76.0	2.6
77	77.0	2.7
78	78.0	2.7
79	79.0	2.8
80	80.0	2.8
81	80.9	2.8
82	81.9	2.9
83	82.9	2.9
84	83.9	2.9
85	84.9	3.0
86	85.9	3.0
87	86.9	3.0
88	87.9	3.1
89	88.9	3.1
90	89.9	3.1
91	90.9	3.2
92	91.9	3.2
93	92.9	3.2
94	93.9	3.3
95	94.9	3.3
96	95.9	3.4
97	96.9	3.4
98	97.9	3.4
99	98.9	3.5
100	99.9	3.5
200	199.9	3.0
300	299.8	10.5
Dist.	Dep.	Lat.

88 Deg.

Dist.	3 Deg. Lat.	Dep.
1	1.0	.1
2	2.0	.1
3	3.0	.1
4	4.0	.2
5	5.0	.2
6	6.0	.3
7	7.0	.4
8	8.0	.4
9	9.0	.5
10	10.0	.5
11	11.0	.6
12	12.0	.6
13	13.0	.7
14	14.0	.7
15	15.0	.8
16	16.0	.8
17	17.0	.9
18	18.0	.9
19	19.0	1.0
20	20.0	1.0
21	21.0	1.1
22	22.0	1.1
23	23.0	1.2
24	24.0	1.2
25	25.0	1.3
26	26.0	1.3
27	27.0	1.4
28	28.0	1.5
29	29.0	1.5
30	30.0	1.6
31	31.0	1.6
32	32.0	1.7
33	33.0	1.7
34	34.0	1.8
Dist.	Dep	Lat

87 Deg.

Dist.	3 Deg. Lat.	Dep
35	35.0	1.8
36	36.0	1.9
37	37.0	1.9
38	38.0	2.0
39	39.0	2.0
40	40.0	2.1
41	41.0	2.1
42	42.0	2.2
43	43.0	2.2
44	44.0	2.3
45	45.0	2.3
46	46.0	2.4
47	47.0	2.4
48	48.0	2.5
49	49.0	2.6
50	50.0	2.6
51	50.9	2.7
52	51.9	2.7
53	52.9	2.8
54	53.9	2.8
55	54.9	2.9
56	55.9	2.9
57	56.9	3.0
58	57.9	3.0
59	58.9	3.1
60	59.9	3.1
61	60.9	3.2
62	61.9	3.2
63	62.9	3.3
64	63.9	3.3
65	64.9	3.4
66	65.9	3.5
67	66.9	3.5
68	67.9	3.6
Dist.	Dep	Lat.

87 Deg.

Dist.	3 Deg. Lat	Dep
69	68.9	3.6
70	69.9	3.7
71	70.9	3.7
72	71.9	3.8
73	72.9	3.8
74	73.9	3.9
75	74.9	3.9
76	75.9	4.0
77	76.9	4.0
78	77.9	4.1
79	78.9	4.1
80	79.9	4.2
81	80.9	4.2
82	81.9	4.3
83	82.9	4.3
84	83.9	4.4
85	84.9	4.4
86	85.9	4.5
87	86.9	4.5
88	87.9	4.6
89	88.9	4.6
90	89.9	4.7
91	90.9	4.8
92	91.9	4.8
93	92.9	4.9
94	93.9	4.9
95	94.9	5.0
96	95.9	5.0
97	96.9	5.1
98	97.9	5.1
99	98.9	5.2
100	99.9	5.2
200	199.7	10.5
300	299.6	15.7
Dist.	Dep.	Lat.

87 Deg.

Dist.	4 Deg. Lat.	Dep
1	1.0	.1
2	2.0	.1
3	3.0	.2
4	4.0	.3
5	5.0	.3
6	6.0	.4
7	7.0	.5
8	8.0	.6
9	9.0	6.
10	10.0	.7
11	11.0	.8
12	12.0	.8
13	13.0	.9
14	14.0	1 0
15	15.0	1.0
16	16.0	1.1
17	17.0	1.2
18	18.0	1.3
19	19 0	1.3
20	20.0	1.4
21	20.9	1.5
22	21.9	1.5
23	22.9	1.6
24	23.9	1.7
25	24.9	1.7
26	25.9	1.8
27	26.9	1.9
28	27.9	2.0
29	28.9	2.0
30	29.9	2.1
31	30.9	2.2
32	31.9	2.3
33	32.9	2.3
34	33.9	2.4
Dist.	Dep	Lat.
	86 Deg.	

Dist.	4 Deg. Lat.	Dep
35	34.9	2.5
36	35.9	2.5
37	36.9	2.6
38	37.9	2.7
39	38.9	2.7
40	39.9	2.8
41	40.9	2.9
42	41.9	2.9
43	42 9	3.0
44	43.9	3.1
45	44.9	3.1
46	45.9	3 2
47	46.9	3.3
48	47.9	3.4
49	48.9	3.4
50	49.9	3 5
51	50.9	3 6
52	51.9	3.6
53	52.9	3.7
54	53.9	3.8
55	54.9	3.8
56	55.9	3.9
57	56.9	4.0
58	57.9	4.0
59	58.9	4.1
60	59.9	4.2
61	60.9	4.3
62	61.9	4.3
63	62.9	4.4
64	63.9	4.5
65	64.8	4.5
66	65.8	4.6
67	66.8	4.7
68	67.8	4 8
Dist.	Dep	Lat.
	86 Deg.	

Dist.	4 Deg. Lat.	Dep.
69	68 8	4.8
70	69.8	4.9
71	70.8	5.0
72	71.8	5.0
73	72.8	5.1
74	73.8	5.2
75	74.8	5.2
76	75.8	5.3
77	76.8	5.4
78	77.8	5.5
79	78.8	5.5
80	79.8	5.6
81	80.8	5.7
82	81.8	5.7
83	82.8	5.8
84	83.8	5.9
85	84.8	5.9
86	85.8	6.0
87	86.8	6.1
88	87.8	6.1
89	88.8	6.2
90	89.8	6.3
91	90.8	6.3
92	91.8	6 4
93	92.8	6.5
94	93.8	6.6
95	94.8	6.6
96	95.8	6.7
97	96.8	6.8
98	97.8	6.8
99	98.8	6.9
100	99.8	7.0
200	199.5	14.0
300	299.3	20.9
Dist.	Dep.	Lat
	86 Deg.	

Dist.	5 Deg. Lat.	Dep
1	1.0	.1
2	2.0	.2
3	3.0	.3
4	4.0	.3
5	5.0	.4
6	6.0	.5
7	7.0	.6
8	8.0	.7
9	9.0	.8
10	10.0	.9
11	11.0	1 0
12	12.0	1.0
13	13.0	1.1
14	14.0	1.2
15	15.0	1.3
16	15.9	1.4
17	16.9	1.5
18	17.9	1.6
19	18.9	1.7
20	19.9	1.7
21	20.9	1.8
22	21.9	1.9
23	22.9	2.0
24	23.9	2.1
25	24.9	2.2
26	25.9	2.3
27	26.9	2.4
28	27.9	2.4
29	28.9	2.5
30	29.9	2.6
31	30.9	2.7
32	31.9	2.8
33	32.9	2.9
34	33.9	3.0
Dist.	Dep	Lat.

85 Deg.

Dist.	5 Deg. Lat.	Dep
35	34.9	3.0
36	35.9	3.1
37	36.9	3.2
38	37.9	3 3
39	38.8	3.4
40	39.8	3.5
41	40.8	3.6
42	41.8	3.7
43	42 8	3 7
44	43.8	3.8
45	44.8	3.9
46	45.8	4.0
47	46.8	4.1
48	47.8	4.2
49	48.8	4 3
50	49.8	4.4
51	50.8	4.5
52	51.8	4.5
53	52.8	4.6
54	53.8	4.7
55	54.8	4.8
56	55.8	4.9
57	56.8	5 0
58	57.8	5.1
59	58.8	5.2
60	59.8	5.2
61	60.8	5.3
62	61.8	5.4
63	62.8	5.5
64	63.8	5.6
65	64.8	5.7
66	65.8	5.8
67	66.8	5.8
68	67.7	5.9
Dist.	Dep	Lat.

85 Deg.

Dist.	5 Deg. Lat.	Dep.
69	68.7	6.0
70	69.7	6.1
71	70 7	6.2
72	71.7	6.3
73	72.7	6.4
74	73.7	6.5
75	74.7	6 5
76	75.7	6.6
77	76.7	6.7
78	77.7	6.8
79	78.7	6.9
80	79.7	7.0
81	80.7	7.1
82	81.7	7.1
83	82.7	7.2
84	83.7	7.3
85	84.7	7.4
86	85.7	7.5
87	86.7	7.6
88	87.7	7.7
89	88.7	7.8
90	89.7	7.8
91	90.7	7.9
92	91.6	8 0
93	92.6	8.1
94	93.6	8.2
95	94.6	8.3
96	95.6	8.4
97	96.6	8.4
98	97.6	8.5
99	98.6	8 6
100	99.6	8.7
200	199.2	17.4
300	298.9	26.2
Dist	Dep.	Lat

85 Deg.

Dist.	6 Deg. Lat.	Dep
1	1.0	.1
2	2.0	.2
3	3.0	.3
4	4.0	.4
5	5.0	.5
6	6.0	.6
7	7.0	.7
8	8.0	.8
9	8.9	.9
10	9.9	1.0
11	10 9	1.1
12	11.9	1.2
13	12.9	1.4
14	13.9	1.5
15	14.9	1.6
16	15.9	1.7
17	16.9	1.8
18	17.9	1.9
19	18.9	2.0
20	19.9	2.1
21	20.9	2.2
22	21.9	2.3
23	22.9	2.4
24	23.9	2.5
25	24.9	2.6
26	25.9	2.7
27	26.8	2.8
28	27.8	2 9
29	28.8	3.0
30	29.8	3.1
31	30.8	3.2
32	31.8	3.3
33	32.8	3.4
34	33.8	3.5
Dist.	Dep	Lat.
	84 Deg.	

Dist.	6 Deg. Lat.	Dep
35	34.8	3.6
36	35.8	3.8
37	36.8	3 9
38	37.8	4.0
39	38.8	4.1
40	39.8	4.2
41	40.8	4 3
42	41.8	4.4
43	42.8	4.5
44	43.8	4.6
45	44.7	4.7
46	45 7	4.8
47	46.7	4.9
48	47.7	5 0
49	48.7	5.1
50	49.7	5.2
51	50.7	5.3
52	51.7	5.4
53	52.7	5.5
54	53 7	5 6
55	54.7	5.7
56	55.7	5.8
57	56.7	5.9
58	57.7	6.1
59	58.7	6.2
60	59.7	6.3
61	60.7	6.4
62	61.7	6 5
63	62.7	6.6
64	63.7	6.7
65	64.6	6.8
66	65.6	6.9
67	66.6	7.0
68	67.6	7.1
Dist.	Dep	Lat
	84 Deg.	

Dist.	6 Deg. Lat	Dep.
69	68.6	7.2
70	69.6	7.3
71	70.6	7.4
72	71.6	7.5
73	72.6	7.6
74	73.6	7.7
75	74.6	7.8
76	75.6	7.9
77	76.6	8.0
78	77.6	8.1
79	78.6	8.2
80	79.6	8.3
81	80.6	8 5
82	81.5	8.6
83	82.5	8.7
84	83.5	8.8
85	84.5	8.9
86	85.5	9.0
87	86.5	9 1
88	87.5	9.2
89	88.5	9.3
90	89.5	9.4
91	90.5	9.5
92	91.5	9.6
93	92.5	9.7
94	93.5	9.8
95	94.5	9 9
96	95.5	10 0
97	96.5	10.1
98	97.5	10.2
99	98.5	10.3
100	99.5	10.4
200	198.9	20.9
300	298.3	31.3
Dist	Dep.	Lat.
	84 Deg.	

Dist.	7 Deg. Lat.	Dep
1	1.0	.1
2	2.0	.2
3	3.0	.4
4	4.0	.5
5	5.0	.6
6	6.0	.7
7	7.9	.8
8	8.9	1.0
9	8.9	1.1
10	9.9	1.2
11	10 9	1.3
12	11.9	1.5
13	12.9	1.6
14	13 9	1.7
15	14.9	1.8
16	15.9	2.0
17	16.9	2.1
18	17.9	2.2
19	18.9	2.3
20	19.9	2.4
21	20.8	2.6
22	21.8	2.7
23	22.8	2.8
24	23.8	2.9
25	24.8	3.0
26	25.8	3.2
27	26.8	3.3
28	27 8	3.4
29	28.8	3.5
30	29.8	3.7
31	30.8	3.8
32	31.8	3.9
33	32.7	4.0
34	33.7	4.1
Dist.	Dep	Lat.
	83 Deg.	

Dist.	7 Deg. Lat.	Dep
35	34.7	4.3
36	35.7	4.4
37	36.7	4.6
38	37.7	4.7
39	38.7	4.8
40	39.7	4.9
41	40.7	5.0
42	41.7	5.1
43	42.7	5.2
44	43.7	5.4
45	44.7	5.5
46	45 6	5.6
47	46.6	5 7
48	47.6	5 9
49	48.6	6.0
50	49.6	6.1
51	50.6	6.2
52	51.6	6.3
53	52.6	6.5
54	53 6	6.6
55	54.6	6.7
56	55.6	6.8
57	56.6	6.9
58	57.6	7.1
59	58.6	7.2
60	59.6	7.3
61	60.5	7.4
62	61.5	7.6
63	62.5	7.7
64	63.5	7.8
65	64.5	7.9
66	65.5	8.1
67	66.5	8.2
68	67.5	8.3
Dist.	Dep	Lat
	83 Deg.	

Dist.	7 Deg. Lat	Dep.
69	68.5	8.4
70	69.5	8.5
71	70.	8 7
72	71.5	8.8
73	72.5	8.9
74	73.4	9.0
75	74.4	9 2
76	75.4	9.3
77	76.4	9.4
78	77.4	9.5
79	78.4	9.6
80	79.4	9 8
81	80.4	9.9
82	81.4	10 0
83	82.4	10.1
84	83.4	10.3
85	84.4	10.4
86	85.4	10.5
87	86.3	10.6
88	87.3	10.7
89	88.3	10.9
90	89.3	11.0
91	90.3	11.1
92	91.3	11.2
93	92.3	11.3
94	93.3	11.5
95	94.3	11.6
96	95.3	11.7
97	96.3	11.8
98	97.3	12.0
99	98.3	12.1
100	99.3	12.2
200	198.5	24 4
300	297.7	36.6
Dist	Dep.	Lat.
	83 Deg.	

Dist.	8 Deg. Lat	Dep
1	1.0	.1
2	2.0	.3
3	3.0	.4
4	4.0	.6
5	5.0	.8
6	5.9	.9
7	6.9	1.0
8	7.9	1.1
9	8.9	1 3
10	9 9	1.4
11	10.9	1.5
12	11.9	1.7
13	12.9	1.8
14	13 9	1.9
15	14.8	2.1
16	15.8	2.2
17	16.8	2.4
18	17.8	2.5
19	18.8	2.6
20	19.8	2 8
21	20.8	2.9
22	21.8	3.1
23	22.8	3.2
24	23.8	3.3
25	24.8	3.5
26	25.7	3.6
27	26.7	3.8
28	27.7	3.9
29	28.7	4 0
30	29.7	4.2
31	30.7	4.3
32	31.7	4.4
33	32.7	4.6
34	33.7	4 7
Dist.	Dep	Lat.

82 Deg.

Dist.	8 Deg Lat	Dep
35	34.7	4.9
36	35.7	5.0
37	36.6	5.1
38	37.6	5.3
39	38 6	5.4
40	39.6	5.6
41	40.6	5 7
42	41.6	5.8
43	42.6	6.0
44	43 6	6.1
45	44.6	6.3
46	45.6	6.4
47	46.5	6.5
48	47.5	6.7
49	48.5	6.8
50	49.5	7.0
51	50.5	7.1
52	51.5	7.2
53	52.5	7 4
54	53.5	7.5
55	54.5	7.7
56	55.5	7.8
57	56.5	7.9
58	57.4	8.1
59	58.4	8.2
60	59.4	8.3
61	60.4	8.5
62	61.4	8.6
63	62.4	8.8
64	63.4	8.9
65	64.4	9.0
66	65.4	9.2
67	66.4	9.3
68	67.3	9.5
Dist.	Dep	Lat

82 Deg.

Dist.	8 Deg. Lat	Dep.
69	68.3	9 6
70	69 3	9.7
71	70.3	9.9
72	71.3	10.0
73	72.3	10.2
74	73.3	10.3
75	74.3	10.4
76	75.3	10.6
77	76.3	10.7
78	77.2	10.9
79	78.2	11.0
80	79.2	11.1
81	80.2	11.3
82	81.2	11.4
83	82.2	11.5
84	83 2	11.7
85	84.2	11.8
86	85.2	12 0
87	86.2	12.1
88	87.2	12.2
89	88.1	12.4
90	89.1	12.5
91	90.1	12.7
92	91.1	12.8
93	92.1	12.9
94	93.1	13.1
95	94.1	13.2
96	95 1	13.4
97	96.1	13.5
98	97.0	13.6
99	98.0	13.8
100	99.0	13.9
200	198.0	27 8
300	297.1	41.8
Dist.	Dep	Lat.

82 Deg.

Dist.	9 Deg. Lat.	Dep
1	1.0	.2
2	2.0	.3
3	3.0	.5
4	4.0	.6
5	4.9	.8
6	5.9	.9
7	6.9	1.1
8	7.9	1.3
9	8.9	1.4
10	9.9	1.6
11	10.9	1.7
12	11.9	1.9
13	12.9	2.0
14	13.8	2.2
15	14.8	2.3
16	15.8	2.5
17	16.8	2.6
18	17.8	2.8
19	18.8	3.0
20	19.8	3.1
21	20.8	3.3
22	21.7	3.4
23	22.7	3.6
24	23.7	3.7
25	24.7	3.9
26	25.7	4.1
27	26.7	4.2
28	27.7	4.4
29	28.7	4.5
30	29.6	4.7
31	30.6	4.8
32	31.6	5.0
33	32.6	5.1
34	33.6	5.3
Dist.	Dep	Lat.

81 Deg.

Dist.	9 Deg Lat	Dep
35	34.6	5.5
36	35.6	5.6
37	36.6	5.8
38	37.5	5.9
39	38.5	6.1
40	39.5	6.3
41	40.5	6.4
42	41.5	6.6
43	42.5	6.7
44	43.5	6.9
45	44.5	7.0
46	45.4	7.2
47	46.4	7.3
48	47.4	7.5
49	48.4	7.7
50	49.4	7.8
51	50.4	8.0
52	51.4	8.1
53	52.4	8.3
54	53.4	8.4
55	54.3	8.6
56	55.3	8.8
57	56.3	8.9
58	57.3	9.1
59	58.3	9.2
60	59.3	9.4
61	60.3	9.5
62	61.2	9.7
63	62.2	9.8
64	63.2	10.0
65	64.2	10.2
66	65.2	10.3
67	66.2	10.5
68	67.2	10.6
Dist.	Dep	Lat.

81 Deg

Dist.	9 Deg. Lat	Dep.
69	68.2	10.8
70	69.1	10.9
71	70.1	11.1
72	71.1	11.2
73	72.1	11.4
74	73.1	11.6
75	74.1	11.7
76	75.1	11.9
77	76.1	12.0
78	77.0	12.2
79	78.0	12.4
80	79.0	12.5
81	80.0	12.7
82	81.0	12.8
83	82.0	13.0
84	83.0	13.1
85	84.0	13.3
86	85.0	13.4
87	85.9	13.6
88	86.9	13.8
89	87.9	13.9
90	88.9	14.1
91	89.9	14.2
92	90.9	14.4
93	91.9	14.5
94	92.9	14.7
95	93.8	14.8
96	94.8	15.0
97	95.8	15.2
98	96.8	15.3
99	97.8	15.5
100	98.8	15.6
200	197.5	21.3
300	296.3	36 9
Dist.	Dep	Lat.

81 Deg.

Dist.	10 Deg. Lat.	Dep
1	1.0	.2
2	2.0	.3
3	3.0	.5
4	3.9	.7
5	4.9	.9
6	5.9	1.0
7	6.9	1.2
8	7.9	1.4
9	8.9	1.6
10	9.9	1.7
11	10.8	1.9
12	11.8	2.1
13	12.8	2.3
14	13.8	2.4
15	14.8	2.6
16	15.8	2.8
17	16.8	3 0
18	17.7	3.1
19	18.7	3.3
20	19.7	3.5
21	20.7	3.6
22	21.7	3.8
23	22.7	4.0
24	23.6	4.2
25	24.6	4.3
26	25.6	4.5
27	26.6	4.7
28	27.6	4.9
29	28.6	5.0
30	29.6	5.2
31	30.5	5.4
32	31.5	5.5
33	32.5	5.7
34	33.5	5.9
Dist.	Dep	Lat
	80 Deg..	

Dist.	10 Deg. Lat.	Dep
35	34.5	6.1
36	35.5	6.2
37	36.5	6.4
38	37.4	6.6
39	38.4	6.8
40	39.4	6.9
41	40.4	7.1
42	41.4	7.3
43	42.4	7.5
44	43.4	7.6
45	44.3	7 8
46	45.3	8.0
47	46 3	8.1
48	47.3	8.3
49	48.3	8.5
50	49.2	8.7
51	50.2	8.8
52	51.2	9.0
53	52.2	9.2
54	53.2	9.4
55	54 2	9.5
56	55.2	9.7
57	56 1	9.9
58	57 1	10:1
59	58.1	10.2
60	59.1	10.4
61	60.1	10.6
62	61.1	10.8
63	62.0	10.9
64	63 0	11.1
65	64.0	11.3
66	65.0	11.5
67	66.0	11.6
68	67.0	11.8
Dist.	Dep	Lat.
	80	Deg

Dist.	10 Deg. Lat	Dep
69	68.0	12.0
70	68.9	12.1
71	69.9	12.3
72	70.9	12.5
73	71.9	12.7
74	72.9	12.8
75	73.9	13.0
76	74.9	13.2
77	75.8	13.3
78	76 8	13.5
79	77 8	13.7
80	78.8	13.9
81	79.8	14.1
82	80.8	14.2
83	81.7	14.4
84	82.7	14.6
85	83.7	14.8
86	84.7	14.9
87	85.7	15.1
88	86.7	15 3
89	87.6	15.4
90	88.6	15.6
91	89.6	15.8
92	90.6	16.0
93	91.6	16 1
94	92 6	16.3
95	93.6	16.5
96	94.6	16.7
97	95.5	16.8
98	96.5	17.0
99	97.5	17.2
100	98.5	17.4
200	197.0	34.7
300	295.4	52.1
Dist.	Dep.	Lat.
	80	Deg.

Dist.	11 Deg. Lat.	Dep
1	1.0	.2
2	2.0	.4
3	2.9	.6
4	3.9	.8
5	4.9	.9
6	5.9	1.1
7	6.9	1.3
8	7.8	1.5
9	8.8	1.7
10	9.8	1.9
11	10.8	2.1
12	11.8	2.3
13	12.8	2.5
14	13.7	2.7
15	14.7	2.9
16	15.7	3.0
17	16.7	3.2
18	17.7	3.4
19	18.6	3.6
20	19.6	3.8
21	20.6	4.0
22	21.6	4.2
23	22.6	4.4
24	23.6	4.6
25	24.5	4.8
26	25.5	5.0
27	26.5	5.1
28	27.5	5.3
29	28.5	5.5
30	29.4	5.7
31	30.4	5.9
32	31.4	6.1
33	32.4	6.3
34	33.4	6.5
Dist.	Dep	Lat.
	79 Deg.	

Dist.	11 Deg. Lat.	Dep
35	34.3	6.7
36	35.3	6.9
37	36.3	7.1
38	37.3	7.2
39	38.3	7.4
40	39.3	7.6
41	40.2	7.8
42	41.2	8.0
43	42.2	8.2
44	43.2	8.4
45	44.2	8.6
46	45.2	8.8
47	46.1	9.0
48	47.1	9.2
49	48.1	9.3
50	49.1	9.5
51	50.1	9.7
52	51.0	9.9
53	52.0	10.1
54	53.0	10.3
55	54.0	10.5
56	55.0	10.7
57	55.9	10.9
58	56.9	11.1
59	57.9	11.2
60	58.9	11.4
61	59.9	11.6
62	60.9	11.8
63	61.8	12.0
64	62.8	12.2
65	63.8	12.4
66	64.8	12.6
67	65.8	12.8
68	66.8	13.0
Dist.	Dep	Lat.
	79 Deg	

Dist.	11 Deg. Lat	Dep
69	67.7	13.2
70	68.	13.4
71	69.7	13.5
72	70.7	13.7
73	71.6	13.9
74	72.6	14.1
75	73.6	14.3
76	74.6	14.5
77	75.6	14.7
78	76.5	14.9
79	77.5	15.1
80	78.5	15.3
81	79.5	15.4
82	80.5	15.6
83	81.5	15.8
84	82.4	16.0
85	83.4	16.2
86	84.4	16.4
87	85.4	16.6
88	86.4	16.8
89	87.3	17.0
90	88.3	17.2
91	89.3	17.4
92	90.3	17.6
93	91.3	17.7
94	92.3	17.9
95	93.2	18.1
96	94.2	18.3
97	95.2	18.5
98	96.2	18.7
99	97.2	18.9
100	98.1	19.1
200	196.3	38.2
300	294.4	57.2
Dist.	Dep.	Lat.
	79 Deg.	

Dist.	12 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.4
3	2.9	.6
4	3.9	.8
5	4.9	1.0
6	5.9	1.2
7	6.8	1.5
8	7.8	1.7
9	8.8	1.9
10	9.8	2.1
11	10.8	2.3
12	11.7	2.5
13	12.7	2.7
14	13.7	2.9
15	14.7	3.1
16	15.6	3.3
17	16.6	3.6
18	17.6	3.8
19	18.6	4.0
20	19.6	4.2
21	20.5	4.4
22	21.5	4.6
23	22.5	4.8
24	23.5	5.0
25	24.5	5.2
26	25.4	5.4
27	26.4	5.6
28	27.4	5.8
29	28.4	6.0
30	29.3	6.2
31	30.3	6.4
32	31.3	6.6
33	32.3	6.9
34	33.3	7.1
Dist.	Dep	Lat.
	78 Deg.	

Dist.	12 Deg. Lat.	Dep
35	34.2	7.3
36	35.2	7.5
37	36.2	7.7
38	37.2	7.9
39	38.1	8.1
40	39.1	8.3
41	40.1	8.5
42	41.1	8.7
43	42.0	9.0
44	43.0	9.2
45	44.0	9.4
46	45.0	9.6
47	46.0	9.8
48	47.0	10.0
49	47.9	10.2
50	48.9	10.4
51	49.9	10.6
52	50.9	10.8
53	51.8	11.0
54	52.8	11.2
55	53.8	11.4
56	54.8	11.6
57	55.8	11.8
58	56.7	12.1
59	57.7	12.3
60	58.7	12.5
61	59.7	12.7
62	60.7	12.9
63	61.6	13.1
64	62.6	13.3
65	63.6	13.7
66	64.6	13.5
67	65.5	14.0
68	66.5	14.2
Dist.	Dep	Lat.
	78 Deg.	

Dist.	12 Deg. Lat.	Dep.
69	67.5	14.4
70	68.5	14.9
71	69.4	14.8
72	70.4	15.0
73	71.4	15.2
74	72.4	15.4
75	73.4	15.6
76	74.3	15.8
77	75.3	16.0
78	76.3	16.2
79	77.3	16.4
80	78.3	16.6
81	79.2	16.8
82	80.2	17.0
83	81.2	17.3
84	82.2	17.5
85	83.1	17.7
86	84.1	17.9
87	85.1	18.1
88	86.1	18.2
89	87.1	18.5
90	88.0	18.7
91	89.0	18.9
92	90.0	19.1
93	91.0	19.3
94	92.0	19.5
95	92.9	19.7
96	93.9	20.0
97	94.9	20.2
98	95.9	20.4
99	96.8	20.6
100	97.8	20.8
200	195.6	41.6
300	293.4	62.4
Dist.	Dep.	Lat
	78 Deg.	

Dist.	13 Deg. Lat.	Dep.
1	1.0	.2
2	2.0	.4
3	2.9	.7
4	3.9	.9
5	4.9	1.1
6	5.9	1.3
7	6.8	1.6
8	7.8	1.8
9	8.8	2.0
10	9.8	2.2
11	10.7	2.5
12	11.7	2.7
13	12.7	2.9
14	13.6	3.1
15	14.7	3.4
16	15.6	3.6
17	16.6	3.8
18	17.6	4.0
19	18.5	4.3
20	19.5	4.5
21	20.5	4.7
22	21.5	4.9
23	22.4	5.2
24	23.4	5.4
25	24.4	5.6
26	25.4	5.8
27	26.3	6.1
28	27.3	6.3
29	28.3	6.5
30	29.2	6.7
31	30.2	7.0
32	31.2	7.2
33	32.2	7.4
34	33.1	7.6
Dist.	Dep	Lat.

77 Deg.

Dist.	13 Deg. Lat.	Dep
35	34.1	7.9
36	35.1	8.1
37	36.1	8.3
38	37.0	8.6
39	38.0	8.8
40	39.0	9.0
41	40.0	9.2
42	40.9	9.4
43	41.9	9.7
44	42.9	9.9
45	43.8	10.1
46	44.8	10.3
47	45.8	10.6
48	46.8	10.8
49	47.7	11.0
50	48.7	11.2
51	49.7	11.5
52	50.7	11.7
53	51.6	11.9
54	52.6	12.1
55	53.6	12.4
56	54.6	12.6
57	55.5	12.8
58	56.5	13.0
59	57.5	13.3
60	58.5	13.5
61	59.4	13.7
62	60.4	14.0
63	61.4	14.2
64	62.4	14.4
65	63.4	14.6
66	64.3	14.8
67	65.3	15.1
68	66.3	15.3
Dist.	Dep	Lat.

77 Deg.

Dist.	13 Deg. Lat.	Dep.
69	67.2	15.5
70	68.2	15.7
71	69.2	16.0
72	70.2	16.2
73	71.1	16.4
74	72.1	16.6
75	73.1	16.9
76	74.1	17.1
77	75.0	17.3
78	76.0	17.5
79	77.0	17.8
80	78.0	18.0
81	78.9	18.2
82	79.9	18.4
83	80.9	18.7
84	81.8	18.9
85	82.8	19.1
86	83.8	19.3
87	84.8	19.6
88	85.7	19.8
89	86.7	20.0
90	87.7	20.2
91	88.7	20.5
92	89.6	20.7
93	90.6	20.9
94	91.6	21.1
95	92.6	21.4
96	93.5	21.6
97	94.5	21.8
98	95.5	22.1
99	96.5	22.3
100	97.4	22.5
200	194.9	45.0
300	292.3	67.5
Dist.	Dep.	Lat

77 Deg.

Dist.	14 Deg. Lat.	Dep
1	1.0	.3
2	1.9	.5
3	2.9	.7
4	3.9	1.0
5	4.8	1.2
6	5.8	1.4
7	6.8	1.7
8	7.8	1.9
9	8.7	2.2
10	9.7	2.4
11	10.7	2.7
12	11.6	2.9
13	12.6	3.1
14	13.6	3.4
15	14.6	3.6
16	15.5	3.9
17	16.5	4.1
18	17.5	4.4
19	18.4	4.6
20	19.4	4.8
21	20.4	5.1
22	21.3	5.3
23	22.3	5.6
24	23.3	5.8
25	24.2	6.0
26	25.2	6.3
27	26.2	6.5
28	27.2	6.8
29	28.1	7.0
30	29.1	7.3
31	30.1	7.5
32	31.0	7.7
33	32.0	8.0
34	33.0	8.2
Dist.	Dep	Lat.

76 Deg.

Dist.	14 Deg. Lat.	Dep
35	34.0	8.5
36	34.9	8.7
37	35.9	9.0
38	36.9	9.2
39	37.8	9.4
40	38.8	9.7
41	39.8	9.9
42	40.7	10.2
43	41.7	10.4
44	42.7	10.7
45	43.7	10.9
46	44.6	11.1
47	45.6	11.4
48	46.6	11.6
49	47.5	11.9
50	48.5	12.1
51	49.5	12.3
52	50.4	12.6
53	51.4	12.8
54	52.4	13.1
55	53.4	13.3
56	54.3	13.6
57	55.3	13.8
58	56.3	14.0
59	57.2	14.3
60	58.2	14.5
61	59.2	14.8
62	60.1	15.0
63	61.1	15.3
64	62.1	15.5
65	63.1	15.7
66	64.0	16.0
67	65.0	16.2
68	66.0	16.5
Dist.	Dep	Lat.

76 Deg.

Dist.	14 Deg. Lat	Dep.
69	66.9	16.7
70	67.9	16.9
71	68.9	17.2
72	69.8	17.4
73	70.8	17.7
74	71.8	17.9
75	72.8	18.2
76	73.7	18.4
77	74.7	18.7
78	75.7	18.9
79	76.6	19.1
80	77.6	19.4
81	78.6	19.5
82	79.6	19.7
83	80.5	20.0
84	81.5	20.2
85	82.5	20.5
86	83.4	20.7
87	84.4	20.9
88	85.4	21.3
89	86.4	21.5
90	87.3	21.8
91	88.3	22.0
92	89.3	22.3
93	90.2	22.5
94	91.2	22.7
95	92.1	23.0
96	93.1	23.2
97	94.1	23.5
98	95.1	23.7
99	96.0	24.0
100	97.0	24.2
200	194.1	48.4
300	291.1	72.6
Dist	Dep.	Lat.

76 Deg.

Dist.	15 Deg. Lat.	Dep
1	1.0	.3
2	1.9	.5
3	2.9	.8
4	3.9	1.0
5	4.8	1.3
6	5.8	1.6
7	6.8	1.8
8	7.7	2.1
9	8.7	2.3
10	9.7	2.6
11	10.6	2.8
12	11.6	3.1
13	12.6	3.4
14	13.5	3.6
15	14.5	3.9
16	15.5	4.1
17	16.4	4.4
18	17.4	4.7
19	18.3	4.9
20	19.3	5.2
21	20.3	5.4
22	21.3	5.7
23	22.2	6.0
24	23.2	6.2
25	24.2	6.5
26	25.1	6.7
27	26.1	7.0
28	27.1	7.3
29	28.0	7.5
30	29.0	7.8
31	29.9	8.0
32	30.9	8.3
33	31.9	8.5
34	32.8	8.8
Dist.	Dep	Lat.
	75 Deg.	

Dist.	15 Deg. Lat.	Dep
35	33.8	9.1
36	34.8	9.3
37	35.7	9.6
38	36.7	9.8
39	37.7	10.1
40	38.6	10.3
41	39.6	10.6
42	40.6	10.9
43	41.5	11.1
44	42.5	11.4
45	43.5	11.6
46	44.4	11.9
47	45.4	12.3
48	46.4	12.5
49	47.3	12.8
50	48.3	12.9
51	49.3	13.2
52	50.2	13.5
53	51.2	13 7
54	52.2	14.0
55	53 1	14.2
56	54.1	14.5
57	55.1	14.8
58	56.0	15.0
59	57.0	15 3
60	58.0	15.5
61	58.9	15.8
62	59.9	16.0
63	60.8	16.3
64	61.8	16.6
65	62.8	16.8
66	63.8	17.1
67	64.7	17.4
68	65.7	17.6
Dist.	Dep	Lat
	75 Deg.	

Dist.	15 Deg. Lat	Dep.
69	66.6	17.9
70	67.6	18.1
71	68.6	18.4
72	69.6	18.6
73	70.6	18.9
74	71.5	19.2
75	72.4	194
76	73.4	19.7
77	74.4	200
78	75.4	20.2
79	76.3	20.5
80	77.3	20.7
81	78.3	21.0
82	79.2	21.2
83	80.2	21.5
84	81.1	21.7
85	82.1	22.0
86	83.1	22 3
87	84.0	22.5
88	85.0	22.8
89	86.0	230
90	86.9	23.3
91	87.9	23.6
92	88 9	23.8
93	89.8	24.1
94	90.8	24.3
95	91.8	24.6
96	92.7	24.8
97	93.7	251
98	94.7	25.4
99	95.6	25.6
100	96.6	25.9
200	193.2	51.8
300	289.8	71.6
Dist.	Dep.	Lat.
	75 Deg.	

Dist.	16 Deg. Lat.	Dep
1	1.0	.3
2	1.9	.6
3	2.9	.8
4	3.8	1.1
5	4.8	1.4
6	5.8	1.7
7	6.7	1.9
8	7.7	2.2
9	8.6	2.5
10	9.6	2.8
11	10.6	3.0
12	11.5	3.3
13	12.5	3.6
14	13.4	3.9
15	14.4	4.1
16	15.4	4.4
17	16.3	4.7
18	17.3	5.0
19	18.3	5.3
20	19.2	5.5
21	20.2	5.8
22	21.1	6.1
23	22.1	6.3
24	23.1	6.6
25	24.0	6.9
26	25.0	7.2
27	25.9	7.5
28	26.9	7.7
29	27.9	8.0
30	28.8	8.3
31	29.8	8.5
32	30.8	8.8
33	31.7	9.1
34	32.7	9.4
Dist.	Dep	Lat.
	74 Deg.	

Dist.	16 Deg Lat	Dep
35	33.6	9.7
36	34.6	9.9
37	35.6	10.2
38	36.5	10.5
39	37.5	10.7
40	38.4	11.0
41	39.4	11.3
42	40.4	11.6
43	41.3	11.9
44	42.3	12.1
45	43.2	12.4
46	44.2	12.7
47	45.2	13.0
48	46.1	13.2
49	47.1	13.5
50	48.1	13.8
51	49.0	14.1
52	50.0	14.3
53	50.9	14.6
54	51.9	14.9
55	52.9	15.1
56	53.8	15.4
57	54.8	15.7
58	55.7	16.0
59	56.7	16.3
60	57.7	16.5
61	58.6	16.8
62	59.6	17.4
63	60.6	17.1
64	61.5	17.7
65	62.5	17.9
66	63.4	18.2
67	64.4	18.5
68	65.4	18.8
Dist.	Dep	Lat.
	74 Deg	

Dist.	16 Deg. Lat	Dep.
69	66.3	19.0
70	67.3	19.3
71	68.2	19.6
72	69.2	19.9
73	70.2	20.1
74	71.1	20.4
75	72.1	20.7
76	73.1	21.0
77	74.0	21.3
78	75.0	21.5
79	75.9	21.8
80	76.9	22.0
81	77.9	22.3
82	78.8	22.6
83	79.8	22.9
84	80.7	23.2
85	81.7	23.5
86	82.7	23.7
87	83.6	24.0
88	84.6	24.3
89	85.6	24.5
90	86.5	24.8
91	87.5	25.1
92	88.4	25.4
93	89.4	25.7
94	90.4	25.9
95	91.3	26.2
96	92.3	26.5
97	93.2	26.7
98	94.2	27.0
99	95.2	27.3
100	96.1	27.6
200	192.2	55.1
300	288.4	82.7
Dist.	Dep	Lat.
	74 Deg.	

Dist.	17 Deg. Lat.	Dep
1	1.0	.3
2	1.9	.6
3	2.9	.9
4	3.8	1.2
5	4.8	1.5
6	5.7	1.7
7	6.7	2.0
8	7.6	2.3
9	8.6	2.6
10	9 6	2 9
11	10.5	3.2
12	11.5	3.5
13	12.4	3.8
14	13 4	4 1
15	14.3	4.4
16	15.3	4.7
17	16.2	5.0
18	17.2	5.2
19	18.2	5.5
20	19.1	5.8
21	20.1	6.1
22	21.0	6.4
23	22.0	6.7
24	23.0	7.0
25	23.9	7.3
26	24.9	7.6
27	25.8	7.9
28	26.8	8.2
29	27.7	8.5
30	28.7	8.8
31	29.6	9.1
32	30.6	9.3
33	31.6	9.6
34	32.9	9.9
Dist.	Dep	Lat.

73 Deg.

Dist.	17 Deg. Lat	Dep
35	33.5	10.2
36	34.4	10.5
37	35.4	10.8
38	36.3	11.1
39	37.3	11.4
40	38.3	11.7
41	39.2	12.0
42	40.2	12.3
43	41.1	12.6
44	42.1	12.9
45	43.0	13.1
46	44.0	13.4
47	44.9	13.7
48	45.9	14.0
49	46.9	14.3
50	47.8	14.6
51	48.8	14.9
52	49.7	15.2
53	50.7	15.5
54	51.6	15.8
55	52 6	16.1
56	53.5	16.4
57	54.5	16.7
58	55.4	17.0
59	56.4	17.2
60	57.4	17.5
61	58.3	17.8
62	59.3	18.1
63	60.2	18.4
64	61.2	18.7
65	62.2	19.0
66	63.1	19.3
67	64.1	19.6
68	65.0	19.9
Di	Dep	Lat.

73 Deg

Dist.	17 Deg. Lat	Dep.
69	66.0	20.2
70	66.9	20.5
71	67.9	20.7
72	68.8	21.0
73	69.8	21.3
74	70.8	21.6
75	71.7	21.9
76	72.7	22.2
77	73.6	22.5
78	74.6	22.8
79	75.5	23.1
80	76.5	23.4
81	77.5	23.7
82	78.4	24.0
83	79.4	24.3
84	80.3	24.6
85	81.3	24.8
86	82.2	25.1
87	83.2	25.4
88	84.2	25.7
89	85.1	26.0
90	86 1	26 3
91	87.0	26.6
92	88.0	26 9
93	88.9	27 2
94	89.9	27.5
95	90.8	27.8
96	91.8	28 1
97	92.7	28.4
98	93.7	28.7
99	94.7	28.9
100	95 6	29.2
200	191.3	58.5
300	286.9	87.7
Dist.	Dep	Lat.

73 Deg.

Dist.	18 Deg. Lat.	Dep
1	1.0	.3
2	1.9	.6
3	2.8	.9
4	3.8	1.2
5	4.7	1.5
6	5.7	1.8
7	6.6	2.2
8	7.6	2.5
9	8.5	2.8
10	9.5	3.1
11	10.4	3.4
12	11.4	3.7
13	12.3	4.0
14	13.3	4.3
15	14.2	4.6
16	15.2	5.0
17	16.1	5.3
18	17.1	5.6
19	18.0	5.9
20	19.0	6.2
21	20.0	6.5
22	20.9	6.8
23	21.9	7.1
24	22.8	7.4
25	23.8	7.7
26	24.7	8.1
27	25.7	8.4
28	26.6	8.7
29	27.6	9.0
30	28.5	9.3
31	29.5	9.6
32	30.4	9.9
33	31.4	10.2
34	32.3	10.5
Dist.	Dep	Lat.
	72 Deg.	

Dist.	18 Deg. Lat.	Dep
35	33.3	10.8
36	34.2	11.1
37	35.2	11.4
38	36.1	11.7
39	37.1	12.0
40	38.0	12.4
41	39.0	12.7
42	39.8	13.0
43	40.8	13.3
44	41.7	13.6
45	42.7	13.9
46	43.6	14.2
47	44.6	14.5
48	45.5	14.8
49	46.5	15.1
50	47.5	15.4
51	48.5	15.8
52	49.5	16.1
53	50.4	16.4
54	51.4	16.7
55	52.3	17.0
56	53.3	17.3
57	54.2	17.6
58	55.2	17.9
59	56.1	18.2
60	57.1	18.5
61	58.0	18.8
62	59.0	19.2
63	59.9	19.5
64	60.9	19.8
65	61.8	20.1
66	62.8	20.4
67	63.7	20.7
68	64.7	21.0
Dist.	Dep	Lat.
	72 Deg.	

Dist.	18 Deg Lat	Dep.
69	65.6	21.3
70	66.6	21.6
71	67.5	21.9
72	68.5	22.2
73	69.4	22.5
74	70.4	22.9
75	71.3	23.2
76	72.3	23.5
77	73.2	23.8
78	74.2	24.1
79	75.1	24.4
80	76.1	24.7
81	77.0	25.0
82	78.0	25.3
83	78.9	25.6
84	79.9	26.0
85	80.8	26.3
86	81.8	26.6
87	82.7	26.9
88	83.7	27.2
89	84.6	27.5
90	85.6	27.8
91	86.5	28.1
92	87.5	28.4
93	88.4	28.7
94	89.4	29.0
95	90.3	29.3
96	91.3	29.7
97	92.2	30.0
98	93.2	30.3
99	94.1	30.6
100	95.1	30.9
200	190.2	61.8
300	285.3	92.7
Dist.	Dep.	Lat.
	72 Deg.	

Dist.	14 Deg. Lat.	Dep
1	.9	.3
2	1.9	.6
3	2.8	1.0
4	3.8	1.3
5	4.7	1.6
6	5.7	2.0
7	6.6	2.3
8	7.5	2.6
9	8.5	2.9
10	9.4	3.3
11	10.4	3.6
12	11.3	3.9
13	12.3	4.2
14	13.2	4.6
15	14.2	4.9
16	15.1	5.2
17	16.1	5.5
18	17.0	5.9
19	18.0	6.2
20	18.9	6.5
21	19.9	6.8
22	20.8	7.2
23	21.7	7.5
24	22.7	7.8
25	23.6	8.2
26	24.6	8.5
27	25.5	8.8
28	26.5	9.1
29	27.4	9.4
30	28.4	9.8
31	29.3	10.1
32	30.3	10.4
33	31.2	10.7
34	32.1	11.1
Dist.	Dep	Lat.
	71 Deg.	

Dist.	19 Deg. Lat.	Dep
35	33.1	11.4
36	34.0	11.7
37	35.0	12.1
38	35.9	12.4
39	36.9	12.7
40	37.8	13.0
41	38.8	13.4
42	39.7	13.7
43	40.7	14.0
44	41.6	14.3
45	42.5	14.7
46	43.5	15.0
47	44.4	15.3
48	45.4	15.6
49	46.3	16.0
50	47.3	16.3
51	48.2	16.6
52	49.2	16.9
53	50.1	17.3
54	51.0	17.6
55	52.0	17.9
56	52.9	18.2
57	53.9	18.6
58	54.8	18.9
59	55.8	19.2
60	56.7	19.5
61	57.7	19.9
62	58.6	20.2
63	59.6	20.5
64	60.5	20.8
65	61.5	21.2
66	62.4	21.5
67	63.4	21.8
68	64.3	22.2
Dist.	Dep	Lat.
	71 Deg	

Dist.	19 Deg. Lat	Dep
69	65.2	22.5
70	66.2	22.8
71	67.1	23.1
72	68.1	23.4
73	69.0	23.8
74	69.9	24.1
75	70.9	24.4
76	71.8	24.7
77	72.8	25.1
78	73.7	25.4
79	74.7	25.7
80	75.6	26.1
81	76.6	26.4
82	77.5	26.7
83	78.5	27.0
84	79.4	27.4
85	80.4	27.7
86	81.3	28.0
87	82.2	28.3
88	83.2	28.7
89	84.1	29.0
90	85.1	29.3
91	86.0	29.6
92	87.0	30.0
93	87.9	30.3
94	88.9	30.6
95	89.8	30.9
96	90.8	31.3
97	91.7	31.6
98	92.6	31.9
99	93.6	32.2
100	94.5	32.6
200	189.1	65.1
300	283.6	97.7
Dist.	Dep.	Lat.
	71 Deg.	

Dist.	20 Deg. Lat.	Dep
1	.9	.3
2	1.9	.7
3	2.8	1.0
4	3.8	1.4
5	4.7	1.7
6	5.6	2.0
7	6.6	2.4
8	7.5	2.7
9	8.5	3.1
10	9.4	3.4
11	10.3	3.8
12	11.3	4.1
13	12.2	4.4
14	13.2	4.8
15	14.1	5.1
16	15.0	5.5
17	16.0	5.8
18	16.9	6.1
19	17.9	6.5
20	18.8	6.8
21	19.7	7.2
22	20.7	7.5
23	21.6	7.9
24	22.6	8.2
25	23.5	8.5
26	24.4	8.9
27	25.4	9.2
28	26.3	9.6
29	27.2	10.0
30	28.2	10.3
31	29.1	10.6
32	30.1	10.9
33	31.0	11.3
34	31.9	11.6
Dist.	Dep	Lat.
	70 Deg	

Dist.	20 Deg Lat	Dep
35	32.9	12.0
36	33.8	12.3
37	34.8	12.6
38	35.7	13.0
39	36.6	13.3
40	37.6	13.7
41	38.5	14.0
42	39.5	14.4
43	40.4	14.7
44	41.3	15.0
45	42.3	15.4
46	43.2	15.7
47	44.2	16.4
48	45.1	16.1
49	46.0	16.8
50	47.0	17.1
51	47.9	17.4
52	48.9	17.8
53	49.8	18.1
54	50.7	18.5
55	51.7	18.8
56	52.6	19.1
57	53.6	19.5
58	54.5	19.8
59	55.4	20.2
60	56.4	20.5
61	57.3	20.9
62	58.3	21.2
63	59.2	21.5
64	60.1	21.9
65	61.1	22.2
66	62.0	22.6
67	63.0	22.9
68	63.9	23.3
Dist.	Dep.	Lat.
	70 Deg	

Dist.	20 Deg. Lat	Dep.
69	64.8	23.6
70	65.8	23.9
71	66.7	24.3
72	67.7	24.6
73	68.6	25.0
74	69.5	25.3
75	70.5	25.6
76	71.4	26.0
77	72.4	26.3
78	73.3	26.7
79	74.2	27.0
80	75.2	27.4
81	76.1	27.7
82	77.1	28.0
83	78.0	28.4
84	78.9	28.7
85	80.0	29.1
86	80.8	29.4
87	81.8	29.8
88	82.7	30.1
89	83.6	30.4
90	84.6	30.8
91	85.5	31.1
92	86.4	31.5
93	87.4	31.8
94	88.3	32.1
95	89.3	32.5
96	90.2	32.8
97	91.2	33.2
98	92.1	33.5
99	93.0	33.9
100	94.0	34.2
200	185.9	68.4
300	281.9	102.6
Dist.	Dep	Lat.
	70 Deg.	

Diff.	21 Deg. Lat.	Dep
1	.9	.4
2	1.9	.7
3	2.8	1.1
4	3.7	1 4
5	4.7	1.8
6	5.6	2.1
7	6.5	2.5
8	7.5	2.9
9	8.4	3.2
10	9.3	3.6
11	10.3	3.9
12	11.2	4 3
13	12.1	4.7
14	13 1	5.0
15	14.0	5.4
16	14.9	5.7
17	15.9	6.1
18	16.8	6.4
19	17.7	6.8
20	18.7	7.2
21	19.6	7.5
22	20.5	7.9
23	21.5	8.2
24	22.4	8.6
25	23 3	9.0
26	24.3	9.3
27	25.2	9.7
28	26.1	10.0
29	27.1	10.4
30	28.0	10.7
31	28.9	11.1
32	29.9	11.5
33	30.8	11 8
34	31.7	12.2
Diff.	Dep	Lat.
	69 Deg.	

Diff.	21 Deg Lat	Dep
35	32.7	12.5
36	33.6	12.9
37	34.5	13.2
38	35.5	13.6
39	36.4	14.0
40	37.3	14.3
41	38.3	14.7
42	39.2	15.0
43	40.1	15.4
44	41.1	15.8
45	42.0	16.1
46	42.9	16.5
47	43.9	16.8
48	44.8	17.2
49	45.7	17.6
50	46.7	17.9
51	47.6	18.3
52	48.5	18.6
53	49.5	19.0
54	50.4	19.3
55	51.3	197
56	52.3	20.1
57	53.2	20.4
58	54.1	20.8
59	55.1	21.1
60	56.0	21.5
61	56.9	21.9
62	57.9	22.2
63	58.8	22.6
64	59.8	22.9
65	60.7	23.3
66	61.6	23.6
67	62.6	24.0
68	63.5	24.4
Diff	Dep	Lat.
	69 Deg	

Diff.	21 Deg. Lat	Dep.
69	64.4	24.7
70	65.3	25.1
71	66.3	25 4
72	67.2	25.8
73	68.1	26 2
74	69.1	26 5
75	70.0	26 9
76	70.9	27 2
77	71.9	27.6
78	72.8	27.9
79	73.7	28.3
80	74.7	28.7
81	75.6	29.0
82	76.6	29.4
83	77.5	29.7
84	78.4	30.1
85	79 4	30 5
86	80.3	30.8
87	81.2	31.2
88	82.2	31.5
89	83.1	31.9
90	84.0	32.6
91	84.9	32.3
92	85.9	33.0
93	86.8	33.3
94	87.7	33.7
95	88.7	34.0
96	89.6	34.4
97	90.5	34 8
98	91.5	35.1
99	92.4	35.5
100	93.4	35.8
200	186.7	71.7
300	280.1	107.5
Diff.	Dep	Lat.
	69 Deg.	

Dist.	22 Deg. Lat.	Dep
1	.9	.4
2	1.9	.7
3	2.8	1.1
4	3.7	1.5
5	4.6	1.9
6	5.6	2.2
7	6.5	2.6
8	7.4	3.0
9	8.3	3.4
10	9.3	3.7
11	10.2	4.1
12	11.1	4.5
13	12.0	4.9
14	13.0	5.2
15	13.9	5.6
16	14.8	6.0
17	15.7	6.4
18	16.6	6.7
19	17.6	7.1
20	18.5	7.5
21	19.5	7.9
22	20.4	8.2
23	21.3	8.6
24	22.2	9.0
25	23.2	9.4
26	24.1	9.7
27	25.0	10.1
28	26.0	10.5
29	26.9	10.9
30	27.8	11.2
31	28.7	11.6
32	29.7	12.0
33	30.6	12.4
34	31.5	12.7
Dist.	Dep	Lat.
	68 Deg.	

Dist.	22 Deg. Lat.	Dep
35	32.4	13.1
36	33.4	13.5
37	34.3	13.9
38	35.2	14.2
39	36.1	14.6
40	37.1	15.0
41	38.0	15.4
42	38.9	15.7
43	39.9	16.1
44	40.8	16.5
45	41.7	16.9
46	42.6	17.2
47	43.6	17.6
48	44.5	18.0
49	45.4	18.4
50	46.4	18.7
51	47.3	19.1
52	48.2	19.5
53	49.1	19.9
54	50.1	20.2
55	51.0	20.6
56	51.9	21.0
57	52.9	21.4
58	53.8	21.7
59	54.7	22.1
60	55.6	22.5
61	56.6	22.9
62	57.5	23.2
63	58.4	23.6
64	59.4	24.0
65	60.3	24.4
66	61.2	24.7
67	62.1	25.1
68	63.1	25.5
Dist.	Dep	Lat.
	68 Deg.	

Dist.	22 Deg. Lat.	Dep.
69	64.0	25.9
70	64.9	26.2
71	65.8	26.6
72	66.7	27.0
73	67.7	27.4
74	68.6	27.7
75	69.5	28.1
76	70.5	28.5
77	71.4	28.9
78	72.3	29.2
79	73.3	29.6
80	74.2	30.0
81	75.1	30.4
82	76.0	30.7
83	77.0	31.1
84	77.9	31.5
85	78.8	31.9
86	79.7	32.2
87	80.6	32.6
88	81.6	33.0
89	82.5	33.4
90	83.4	33.7
91	84.4	34.1
92	85.3	34.5
93	86.2	34.9
94	87.1	35.2
95	88.1	35.6
96	89.0	36.0
97	89.9	36.4
98	90.9	36.7
99	91.8	37.1
100	92.7	37.5
200	185.4	74.9
300	278.2	109.4
Dist.	Dep.	Lat.
	68 Deg.	

Dist.	23 Deg. Lat.	Dep
1	.9	.4
2	1.8	.8
3	2.8	1.2
4	3.7	1.6
5	4.6	1.9
6	5.5	2.3
7	6.4	2.7
8	7.4	3.1
9	8.3	3.5
10	9.2	3.9
11	10.1	4.3
12	11.0	4.7
13	12.0	5.1
14	12.9	5.5
15	13.8	5.9
16	14.7	6.2
17	15.6	6.6
18	16.6	7.0
19	17.5	7.4
20	18.4	7.8
21	19.3	8.2
22	20.2	8.6
23	21.2	9.0
24	22.1	9.4
25	23.0	9.8
26	23.9	10.2
27	24.8	10.5
28	25.8	10.9
29	26.7	11.3
30	27.6	11.7
31	28.5	12.1
32	29.4	12.5
33	30.4	12.9
34	31.3	13.3
Dist.	Dep	Lat.
	67 Deg.	

Dist.	23 Deg. Lat.	Dep
35	32.2	13.7
36	33.1	14.1
37	34.0	14.4
38	35.0	14.8
39	35.9	15.2
40	36.8	15.6
41	37.7	16.0
42	38.6	16.4
43	39.6	16.8
44	40.5	17.2
45	41.4	17.6
46	42.3	18.0
47	43.3	18.4
48	44.2	18.7
49	45.1	19.1
50	46.0	19.5
51	46.9	19.9
52	47.9	20.3
53	48.8	20.7
54	49.7	21.1
55	50.6	21.5
56	51.5	21.9
57	52.4	22.3
58	53.4	22.6
59	54.3	23.0
60	55.2	23.4
61	56.1	23.8
62	57.1	24.2
63	58.0	24.6
64	58.9	25.0
65	59.8	25.4
66	60.8	25.8
67	61.8	26.2
68	62.6	26.6
Dist.	Dep	Lat
	67 Deg.	

Dist.	23 Deg. Lat.	Dep.
69	63.5	26.9
70	64.4	27.3
71	65.3	27.7
72	66.3	28.1
73	67.2	28.5
74	68.1	28.9
75	69.0	29.3
76	69.9	29.7
77	70.9	30 1
78	71.8	30.5
79	72.7	30.8
80	73.6	31.2
81	74.6	31.6
82	75.5	32.0
83	76.4	32 4
84	77.3	32.8
85	78.2	33 2
86	79.2	33.6
87	80.1	34.0
88	81.0	34.4
89	81.9	34 8
90	82.8	35 2
91	83.8	35.6
92	84.7	36.0
93	85.6	36.3
94	86.5	36.7
95	87.4	37.0
96	88.4	37.5
97	89.3	37.9
98	90.2	38.3
99	91.1	38.7
100	92.0	39.1
200	184.1	78.1
300	276.1	117.2
Dist.	Dep.	Lat.
	67 Deg.	

Dist.	24 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.8
3	2.7	1 2
4	3.6	1.6
5	4.6	2.0
6	5.5	2.4
7	6.4	2.8
8	7.3	3.2
9	8.2	3.7
10	9.1	4.1
11	10.0	4.5
12	10.9	4.9
13	11 9	5.3
14	12.8	5.7
15	13.7	6.1
16	14.6	6.5
17	15.5	6.9
18	16.4	7.3
19	17.3	7.7
20	18.3	8.1
21	19 2	8.5
22	20.1	9.0
23	21.0	9.4
24	21.9	9.8
25	22.8	10.2
26	23.7	10.6
27	24.6	11.0
28	25.6	11.3
29	26.5	11.7
30	27.4	12.2
31	28.3	12.6
32	29.2	13.0
33	30.1	13.4
34	31.0	13.8
Dist.	Dep	Lat.
	66 Deg.	

Dist.	24 Deg. Lat.	Dep
35	32.0	14.2
36	32.9	14.6
37	33.8	15.1
38	34.7	15.5
39	35.6	15.9
40	36.5	16.3
41	37 4	16.7
42	38.4	17.1
43	39 3	17.5
44	40.2	17.9
45	41.1	18 3
46	42 0	18.7
47	42.9	19.1
48	43.8	19 5
49	44.8	19.9
50	45.7	20.3
51	46.6	20.7
52	47.5	21.1
53	48.4	21.6
54	49.3	22.0
55	50.2	22.4
56	51.1	22.8
57	52.1	23.2
58	53.0	23.6
59	53.9	24.0
60	54.8	24.4
61	55.7	24.8
62	56.6	25.2
63	57.5	25.6
64	58.5	26.0
65	59.4	26.4
66	60.3	26 8
67	61.2	27.2
68	62.1	27.6
Dist.	Dep	Lat.
	66 Deg.	

Dist.	24 Deg. Lat.	Dep.
69	63.0	28.1
70	63.9	28.5
71	64.8	28.9
72	65.8	29.3
73	66.7	29.7
74	67.6	30.1
75	68 5	30.5
76	69.4	30.9
77	70 3	31.3
78	71.2	31.7
79	72.1	32.1
80	73.1	32.5
81	74.0	32.9
82	74.9	33.3
83	75.8	33.7
84	76.7	34.1
85	77.6	34 5
86	78.5	34.9
87	79.5	35.3
88	80.4	35.7
89	81.3	36.2
90	82.2	36.6
91	83.1	37.0
92	84.0	37.4
93	84.9	37.8
94	85.8	38 2
95	86.8	38.6
96	87.7	39.0
97	88.6	39.5
98	89.5	39.9
99	90.4	40.3
100	91.3	40.7
200	182.7	81.3
300	274 0	122.0
Dist.	Dep.	Lat
	66 Deg.	

Dist.	25 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.8
3	2.7	1.3
4	3.6	1.7
5	4.5	2.1
6	5.4	2.5
7	6.3	3.0
8	7.2	3.4
9	8.1	3.8
10	9.1	4.2
11	10.0	4.7
12	10.9	5.1
13	11.8	5.5
14	12.7	5.9
15	13.6	6.3
16	14.5	6.8
17	15.4	7.2
18	16.3	7.6
19	17.2	8.0
20	18.1	8.4
21	19.0	8.9
22	19.9	9.3
23	20.8	9.7
24	21.8	10.1
25	22.7	10.6
26	23.6	11.0
27	24.5	11.4
28	25.4	11.8
29	26.3	12.3
30	27.2	12.7
31	28.1	13.1
32	29.0	13.5
33	29.9	14.0
34	30.8	14.4
Dist.	Dep	Lat.
	65 Deg.	

Dist.	25 Deg. Lat.	Dep
35	31.7	14.8
36	32.6	15.2
37	33.5	15.6
38	34.4	16.1
39	35.3	16.5
40	36.2	16.9
41	37.2	17.3
42	38.1	17.8
43	39.0	18.2
44	39.9	18.6
45	40.8	19.0
46	41.7	19.5
47	42.6	19.9
48	43.5	20.3
49	44.4	20.7
50	45.3	21.1
51	46.2	21.6
52	47.1	22.0
53	48.0	22.4
54	48.9	22.8
55	49.8	23.2
56	50.7	23.7
57	51.6	24.1
58	52.6	24.5
59	53.5	25.0
60	54.4	25.4
61	55.3	25.8
62	56.2	26.2
63	57.1	26.7
64	58.0	27.1
65	58.9	27.5
66	59.8	27.9
67	60.7	28.3
68	61.6	28.8
Dist.	Dep	Lat.
	65 Deg.	

Dist.	25 Deg. Lat.	Dep.
69	62.5	29.2
70	63.4	29.6
71	64.3	30.0
72	65.2	30.5
73	66.2	30.9
74	67.1	31.3
75	68.0	31.7
76	68.9	32.1
77	69.8	32.6
78	70.7	33.0
79	71.6	33.4
80	72.5	33.8
81	73.4	34.3
82	74.3	34.7
83	75.2	35.1
84	76.1	35.5
85	77.0	36.0
86	77.9	36.4
87	78.8	36.8
88	79.7	37.2
89	80.7	37.6
90	81.6	38.0
91	82.5	38.4
92	83.4	38.9
93	84.3	39.3
94	85.2	39.7
95	86.1	40.1
96	87.0	40.6
97	87.9	41.0
98	88.8	41.4
99	89.7	41.8
100	90.6	42.3
200	181.3	84.5
300	271.9	126.8
Dist	Dep.	Lat
	65 Deg.	

Dist.	26 Deg. Lat.	Dep.
1	.9	.4
2	1.8	.9
3	2.7	1.3
4	3.6	1.8
5	4.5	2.2
6	5.4	2.6
7	6.3	3.1
8	7.2	3.5
9	8.1	3.9
10	9.0	4.4
11	9.9	4.8
12	10.8	5.3
13	11.7	5.7
14	12.6	6.1
15	13.5	6.6
16	14.4	7.0
17	15.3	7.4
18	16.2	7.9
19	17.1	8.3
20	18.0	8.8
21	18.9	9.2
22	19 8	9.6
23	20.7	10.1
24	21.6	10.5
25	22.5	10.9
26	23.4	11.4
27	24.3	11.8
28	25.2	12.3
29	26.1	12.7
30	27.0	13.1
31	27.9	13.6
32	28.8	14.0
33	29.7	14.4
34	30.6	14.9
Dist.	Dep	Lat.
	64 Deg.	

Dist.	26 Deg. Lat.	Dep
35	31.5	15.3
36	32.4	15.8
37	33.3	16.2
38	34.2	16.6
39	35.1	17.1
40	36.0	17.5
41	36.8	17.9
42	37.8	18 4
43	38.6	18.8
44	39.5	19.3
45	40.4	19 7
46	41.3	20.2
47	42.2	20.6
48	43.1	21.0
49	44.0	21.4
50	44.9	21.9
51	45.8	22.3
52	46.7	22.8
53	47.6	23.2
54	48.5	23.7
55	49.4	24.1
56	50.3	24.5
57	51.2	25.0
58	52.1	25.4
59	53.0	25.8
60	53.9	26.3
61	54.8	26.7
62	55.7	27.2
63	56.6	27.6
64	57.5	28.0
65	58.4	28.5
66	59.3	28.9
67	60.2	29.4
68	61.1	29.8
Dist.	Dep	Lat.
	64 Deg.	

Dist.	26 Deg. Lat.	Dep.
69	62.0	30.2
70	62.9	30.7
71	63.8	31.1
72	64.7	31.6
73	65.6	32.0
74	66.5	32.4
75	67.4	32.9
76	68.3	33.3
77	69.2	33.8
78	70 1	34.2
79	71.0	346
80	71.9	35.1
81	72.8	35.5
82	73.7	35.9
83	74.6	36.4
84	75.5	36.8
85	76.4	37.2
86	77.3	37.7
87	78.2	38.1
88	79.1	38.5
89	80.0	39.0
90	80.9	39.4
91	81.8	39.9
92	82.7	40.3
93	83.6	40.7
94	84.5	41.2
95	85.4	41.6
96	86.3	42.1
97	87.2	42.5
98	88.1	42.9
99	89.0	43.4
100	89.9	43.8
200	179.8	87.7
300	269.6	131.5
Dist.	Dep.	Lat
	64 Deg.	

Dist.	27 Deg. Lat.	Dep.
1	.9	.5
2	1.8	.9
3	2.7	1 4
4	3.6	1.8
5	4.5	2.3
6	5.3	2.7
7	6.2	3.2
8	7.1	3.6
9	8.0	4.1
10	8.9	4.5
11	9.8	5.0
12	10.7	5.4
13	11.6	5.9
14	12.5	6.3
15	13.4	6.8
16	14.3	7.2
17	15.1	7.7
18	16.0	8.2
19	16.9	8.6
20	17.8	9.1
21	18.7	9.5
22	19.6	10.0
23	20.5	10.4
24	21.4	10.9
25	22.3	11.3
26	23.2	11.8
27	24.1	12.2
28	24.9	12.7
29	25.8	13.2
30	26.7	13.6
31	27.6	14.1
32	28.5	14.5
33	29.4	15 0
34	30.3	15.4
Dist.	Dep	Lat.
	63 Deg.	

Dist.	27 Deg. Lat.	Dep
35	31.2	15.9
36	32.1	16 3
37	33.0	16.8
38	33 8	17.2
39	34.7	17.7
40	35.6	18 2
41	36.5	18.6
42	37 4	19.1
43	38.3	19 5
44	39.1	20.0
45	40.1	20.4
46	41.0	20.9
47	41.9	21.3
48	42 8	21.8
49	43.6	22.2
50	44.5	22.7
51	45.4	23.2
52	46.3	23.6
53	47.2	24.1
54	48.1	24.5
55	49.0	25.0
56	49.9	25.4
57	50.8	25.9
58	51.7	26.3
59	52.6	26.8
60	53.5	27.2
61	54.3	27.7
62	55.2	28.2
63	56.1	28 6
64	57.0	29.1
65	57.9	29.5
66	58 8	30.0
67	59.7	30.4
68	60.6	30.9
Dist.	Dep	Lat.
	63 Deg.	

Dist.	27 Deg. Lat.	Dep.
69	61.5	31.3
70	62.4	31.8
71	63.3	32.2
72	64.1	32.7
73	65.0	33.2
74	65.9	33.6
75	66.8	34.1
76	67.7	34 5
77	68 6	35.0
78	69.5	35.4
79	70 4	35 9
80	71.3	36.3
81	72.2	36.8
82	73.1	37.2
83	73.9	37.7
84	74.8	38 1
85	75.7	38.6
86	76.6	39.0
87	77.5	39.5
88	78.4	40.0
89	79.3	40.4
90	80.2	40.9
91	81.1	41.3
92	82.0	41.8
93	82.9	42.2
94	83.7	42.7
95	84.6	43.1
96	85.5	43.6
97	86.4	44.0
98	87.3	44.5
99	88.2	44.9
100	89.1	45.4
200	178.2	90.9
300	267.3	136 3
Dist.	Dep.	Lat
	63 Deg.	

Dist.	28 Deg. Lat.	Dep
1	.9	.5
2	1.8	.9
3	2.6	1.4
4	3.5	1.9
5	4.4	2.3
6	5.3	2.8
7	6.2	3.3
8	7.1	3.7
9	7.9	4.2
10	8.8	4.7
11	9.7	5.2
12	10.6	5.7
13	11.5	6.1
14	12.4	6.6
15	13.2	7.0
16	14.1	7.5
17	15.0	8.0
18	15.9	8.4
19	16.8	8.9
20	17.7	9.4
21	18.5	9.9
22	19.4	10.3
23	20.3	10.8
24	21.2	11.3
25	22.1	11.7
26	23.0	12.2
27	23.8	12.7
28	24.7	13.1
29	25.6	13.6
30	26.5	14.1
31	27.4	14.5
32	28.2	15.0
33	29.1	15.5
34	30.0	16.0
Dist.	Dep	Lat.
	62 Deg.	

Dist.	28 Deg Lat	Dep
35	30.9	16.4
36	31.8	16.9
37	32.6	17.4
38	33.5	17.8
39	34.4	18.3
40	35.3	18.8
41	36.2	19.2
42	37.1	19.7
43	38.0	20.2
44	38.8	20.7
45	39.7	21.1
46	40.6	21.6
47	41.5	22.1
48	42.4	22.5
49	43.2	23.0
50	44.1	23.5
51	45.0	23.9
52	45.9	24.4
53	46.8	24.9
54	47.7	25.4
55	48.5	25.8
56	49.4	26.3
57	50.3	26.8
58	51.2	27.2
59	52.1	27.7
60	53.0	28.2
61	53.8	28.6
62	54.7	29.1
63	55.6	29.6
64	56.5	30.0
65	57.4	30.5
66	58.3	31.0
67	59.1	31.5
68	60.0	31.9
Dist.	Dep	Lat.
	62 Deg	

Dist.	28 Deg. Lat	Dep.
69	60.9	32.4
70	61.8	32.9
71	62.7	33.3
72	63.6	33.8
73	64.4	34.3
74	65.3	34.7
75	66.2	35.2
76	67.1	35.7
77	68.0	36.1
78	68.9	36.6
79	69.7	37.1
80	70.6	37.6
81	71.5	38.0
82	72.4	38.5
83	73.3	39.0
84	74.2	39.4
85	75.0	39.9
86	75.9	40.4
87	76.8	40.8
88	77.7	41.3
89	78.6	41.8
90	79.5	42.2
91	80.3	42.7
92	81.2	43.2
93	82.1	43.7
94	83.0	44.1
95	83.9	44.6
96	84.8	45.1
97	85.6	45.5
98	86.5	46.0
99	87.4	46.5
100	88.3	46.9
200	176.6	93.9
300	264.9	140.8
Dist.	Dep	Lat.
	62 Deg.	

Dist.	29 Deg. Lat.	Dep
1	.9	.5
2	1.7	1.0
3	2.6	1 4
4	3.5	1.9
5	4.4	2.4
6	5.2	2.9
7	6.1	3.4
8	7.0	3.9
9	7.9	4 3
10	8.7	4.8
11	9 6	5.3
12	10.5	5.8
13	11.4	6.3
14	12.2	6.8
15	13 1	7.3
16	14.0	7.7
17	14.9	8 2
18	15.7	8.7
19	16.6	9.2
20	17.5	9.7
21	18.4	10.2
22	19 2	10.7
23	20.1	11.1
24	21.0	11.6
25	21.9	12 1
26	22.7	12.6
27	23 6	13.1
28	24.5	13.6
29	25.4	14.1
30	26.2	14.5
31	27.1	15 0
32	28.0	15.5
33	28.9	16.0
34	29.7	16.5
Dist.	Dep	Lat.

61 Deg.

Dist.	29 Deg Lat	Dep
35	30.6	17.0
36	31.5	17.4
37	32.4	17.9
38	33.2	18 4
39	34.1	18 9
40	35.0	19.4
41	35.9	19 9
42	36.7	20.3
43	37.6	20.3
44	38.5	21.8
45	39.4	21.8
46	40.2	22.3
47	41.1	22.8
48	42.0	23.3
49	42.9	23.7
50	43 7	24.2
51	44.6	24.7
52	45.5	25.2
53	46.4	25.7
54	47.2	26.2
55	48.1	26.7
56	49.0	27.1
57	49.9	27.6
58	50.7	28.1
59	51.6	28 6
60	52 5	29.1
61	53.4	29 6
62	54.2	30.1
63	55.1	30.5
64	56.0	31.0
65	56.9	31.5
66	57.7	32.0
67	58.6	32.5
68	59.5	33.0
Dist.	Dep	Lat.

61 Deg

Dist.	29 Deg. Lat	Dep.
69	60 4	33.4
70	61.2	33.9
71	62.1	34.4
72	63.0	34.9
73	63.8	35.4
74	64.7	35.9
75	65.6	36.3
76	66.5	36.8
77	67.3	37.3
78	68.2	37.8
79	69.1	38.3
80	70.0	38.8
81	70.8	39.3
82	71.7	39.7
83	72.6	40.2
84	73.5	40 7
85	74.3	41.2
86	75.2	41.7
87	76.1	42.2
88	77.0	42.7
89	77.8	43.1
90	78.7	43.6
91	79.6	44 1
92	80.5	44.6
93	81.3	45.1
94	82.2	45 6
95	83.1	46 1
96	84.0	46.5
97	84.8	47.0
98	85.7	47.5
99	86.6	48.0
100	87.5	48.5
200	174.9	97.0
300	262.4	145.4
Dist.	Dep	Lat.

61 Deg.

Dist.	30 Deg. Lat.	Dep
1	.9	.5
2	1.7	1.0
3	2.6	1.5
4	3.5	2.0
5	4.3	2.5
6	5.2	3.0
7	6.1	3.5
8	6.9	4.0
9	7.8	4.5
10	8.7	5.0
11	9.5	5.5
12	10.4	6.0
13	11.3	6.5
14	12.1	7.0
15	13.0	7.5
16	13.9	8.0
17	14.7	8.5
18	15.6	9.0
19	16.5	9.5
20	17.3	10.0
21	18.2	10.5
22	19.1	11.0
23	19.9	11.5
24	20.8	12.0
25	21.7	12.5
26	22.5	13.0
27	23.4	13.5
28	24.2	14.0
29	25.1	14.5
30	26.0	15.0
31	26.8	15.5
32	27.7	16.0
33	28.6	16.5
34	29.4	17.0
Dist.	Dep	Lat.
	60 Deg.	

Dist.	30 Deg. Lat.	Dep
35	30.3	17.5
36	31.2	18.0
37	32.0	18.5
38	32.9	19.0
39	33.8	19.5
40	34.6	20.0
41	35.5	20.5
42	36.4	21.0
43	37.2	21.5
44	38.1	22.0
45	39.0	22.5
46	39.8	23.0
47	40.7	23.5
48	41.6	24.0
49	42.4	24.5
50	43.3	25.0
51	44.2	25.5
52	45.0	26.0
53	45.9	26.5
54	46.8	27.0
55	47.6	27.5
56	48.5	28.0
57	49.4	28.5
58	50.2	29.0
59	51.1	29.5
60	52.0	30.0
61	52.8	30.5
62	53.7	31.0
63	54.6	31.5
64	55.4	32.0
65	56.3	32.5
66	57.2	33.0
67	58.0	33.5
68	58.9	34.0
Dist.	Dep	Lat.
	60 Deg.	

Dist.	30 Deg. Lat.	Dep.
69	59.8	34.5
70	60.6	35.0
71	61.5	35.5
72	62.3	36.0
73	63.2	36.5
74	64.1	37.0
75	64.9	37.5
76	65.8	38.0
77	66.7	38.5
78	67.6	39.0
79	68.4	39.5
80	69.3	40.0
81	70.2	40.5
82	71.0	41.0
83	71.9	41.5
84	72.7	42.0
85	73.5	42.5
86	74.6	43.0
87	75.3	43.5
88	76.2	44.0
89	77.1	44.5
90	77.9	45.0
91	78.8	45.5
92	79.7	46.0
93	80.6	46.5
94	81.4	47.0
95	82.3	47.5
96	83.2	48.0
97	84.0	48.5
98	84.9	49.0
99	85.7	49.5
100	86.6	50.0
200	173.2	100.5
300	259.8	150.0
Dist.	Dep.	Lat.
	60 Deg.	

Dist.	31 Deg. Lat.	Dep
1	.9	.5
2	1.7	1.0
3	2.6	1.5
4	3.4	2.1
5	4.3	2.6
6	5.1	3.1
7	6.0	3.6
8	6.9	4.1
9	7.7	4.6
10	8.6	5.1
11	9.4	5.7
12	10 3	6.2
13	11 1	6.7
14	12.0	7.2
15	12.9	7.7
16	13.7	8.2
17	14.6	8.8
18	15.4	9.3
19	16.3	9.8
20	17.1	10.3
21	18.0	10.8
22	18.9	11.3
23	19.7	11.8
24	20.6	12.4
25	21.4	12.9
26	22.3	13.4
27	23.1	13.9
28	24.0	14.4
29	24.9	14.9
30	25.7	15.4
31	26.6	16.0
32	27.4	16.5
33	28.3	17.0
34	29.2	17.5
Dist.	Dep	Lat.
	59 Deg.	

Dist.	31 Deg. Lat.	Dep
35	30.0	18.0
36	30.9	18.5
37	31.7	19.1
38	32.6	19.6
39	33.4	20.1
40	34.3	20.6
41	35.1	21.1
42	36.0	21.6
43	36.9	22.1
44	37.7	22.7
45	38.6	23.2
46	39.4	23.7
47	40.3	24.2
48	41.1	247
49	42.0	25.2
50	42.9	25.7
51	43.7	26.3
52	44.6	26 8
53	45.4	27.3
54	46.3	27.8
55	47.1	28.3
56	48.0	28.8
57	48.9	29.4
58	49.7	29.9
59	50.6	30.4
60	51.4	30.9
61	52.3	31.4
62	53.1	31.9
63	54.0	32.4
64	54.9	33.0
65	55.7	33.5
66	56.6	34.0
67	57.4	34.5
68	58.3	35.0
Dist.	Dep	Lat.
	59 Deg.	

Dist.	31 Deg. Lat.	Dep.
69	59.1	35.5
70	60.0	36.0
71	60.9	36.6
72	61.7	37.1
73	62.6	37.6
74	63.4	38.1
75	64.3	38.6
76	65.1	39.1
77	66.0	39.7
78	66.9	40.2
79	67.7	40.7
80	68.6	41.2
81	69.4	41.7
82	70.3	42.2
83	71.1	42.7
84	72.0	43 3
85	72.9	43.8
86	73.7	44.3
87	74.6	44.8
88	75.4	45.3
89	76.3	45.8
90	77.1	46.3
91	78.0	46.9
92	78.9	47.4
93	79.7	47.9
94	80.6	48.4
95	81.4	48.9
96	82.3	494
97	83.1	50.0
98	84.0	50.5
99	84.9	51.0
100	85.7	51.5
200	171.4	103.0
300	257.2	154.5
Dist	Dep.	Lat.
	59 Deg.	

Dist.	32 Deg. Lat.	Dep
1	.8	.5
2	1.7	1.1
3	2.5	1.6
4	3 4	2.1
5	4.2	2.6
6	5.0	3 2
7	5.9	3.7
8	6 8	4.2
9	7.6	4.8
10	8.5	5.3
11	9.3	5.8
12	10.2	6.4
13	11.0	6.9
14	11.9	7.4
15	12.7	7.9
16	13.6	8.5
17	14.4	9.0
18	15.3	9.5
19	16.1	10.1
20	17.0	10.6
21	17.8	11.1
22	18.7	11.7
23	19.5	12.2
24	20.4	12.7
25	21.2	13.2
26	22.0	13.8
27	22.9	14.3
28	23.7	14.8
29	24.6	15.3
30	25.4	15.9
31	26.3	16.4
32	27.1	17.0
33	28.0	17.5
34	28.8	18.0
Dist.	Dep	Lat.
	58 Deg.	

Dist.	32 Deg. Lat.	Dep
35	29.7	18.5
36	30.5	19.1
37	31.4	19.6
38	32.2	20.1
39	33.1	20.7
40	33.9	21.2
41	34.8	21.7
42	35.6	22.3
43	36.5	22.8
44	37.3	23.3
45	38.2	23.0
46	39.0	24.4
47	39.8	24 9
48	40.7	25.4
49	41.5	26.0
50	42.4	26.5
51	43.3	27.0
52	44.1	27.5
53	44.9	28.1
54	45.8	28.6
55	46 6	29.1
56	47.5	29.7
57	48.3	30.2
58	49 2	30.7
59	50.0	31.3
60	50.9	31.8
61	51.7	32.3
62	52.6	32.9
63	53.4	33.4
64	54 3	33 0
65	55.1	34 4
66	56 0	35.0
67	56.8	35.5
68	57 7	36.0
Dist.	Dep	Lat.
	58 Deg	

Dist.	32 Deg Lat	Dep.
69	58 5	36.6
70	59.4	37.1
71	60.2	37.6
72	61.0	38.1
73	61 9	38.7
74	62.7	39.2
75	63.6	39.7
76	64.4	40.3
77	65.3	40.8
78	66.1	41.3
79	67.0	41.9
80	67.8	42.4
81	68.7	4 .9
82	69.5	43.4
83	70.3	44.0
84	71.2	44.5
85	72.1	45.0
86	72.9	45 6
87	73.8	46.1
88	74.6	46 6
89	75.5	47.2
90	76.3	47.7
91	77.2	48.2
92	78.0	48.7
93	78.8	49.3
94	79.7	49.8
95	80.5	50.3
96	81.4	50.9
97	82.2	51.4
98	83.1	51.9
99	83.9	52.4
100	84.8	53.0
200	169.6	106.0
300	2544	159.0
Dist.	Dep.	Lat.
	58 Deg.	

Dist.	33 Deg. Lat.	Dep
1	.8	.5
2	1.7	1.1
3	2.5	1.6
4	3.4	2.2
5	4.2	2.7
6	5.0	3.3
7	5.9	3.8
8	6.7	4.4
9	7.6	4.9
10	8.4	5.4
11	9.2	6.0
12	10.1	6.5
13	10.9	7.1
14	11.7	7.6
15	12.6	8.2
16	13.4	8.7
17	14.3	9.3
18	15.1	9.8
19	15.9	10.4
20	16.8	10.9
21	17.6	11.4
22	18.5	12.0
23	19.3	12.5
24	20.1	13.1
25	21.1	13.6
26	21.8	14.2
27	22.7	14.7
28	23.5	15.3
29	24.3	15.8
30	25.2	16.3
31	26.0	16.9
32	26.9	17.4
33	27.7	18.0
34	28.5	18.5
Dist.	Dep	Lat.
	57 Deg.	

Dist.	33 Deg. Lat.	Dep
35	29.4	19.1
36	30.2	19.6
37	31.1	20.2
38	31.9	20.7
39	32.7	21.2
40	33.5	21.8
41	34.4	22.3
42	35.2	22.6
43	36.1	23.4
44	36.9	24.0
45	37.7	24.5
46	38.6	25.1
47	39.4	25.6
48	40.3	26.2
49	41.1	26.7
50	41.9	27.2
51	42.8	27.8
52	43.6	28.3
53	44.5	28.8
54	45.3	29.4
55	46.1	30.0
56	47.0	30.5
57	47.8	31.0
58	48.7	31.6
59	49.5	32.1
60	50.3	32.7
61	51.2	33.2
62	52.0	33.8
63	52.9	34.3
64	53.7	34.8
65	54.5	35.4
66	55.4	35.9
67	56.2	36.5
68	57.1	37.0
Dist.	Dep	Lat.
	57 Deg.	

Dist.	33 Deg Lat	Dep.
69	57.9	37.6
70	58.7	38.1
71	59.6	38.6
72	60.4	39.2
73	61.2	39.7
74	62.1	40.3
75	62.9	40.8
76	63.7	41.4
77	64.6	41.9
78	65.4	42.5
79	66.3	43.0
80	67.1	43.6
81	67.9	44.1
82	68.8	44.6
83	69.6	45.2
84	70.5	45.7
85	71.3	46.2
86	72.1	46.8
87	73.0	47.3
88	73.8	47.9
89	74.7	48.4
90	75.5	49.0
91	76.3	49.5
92	77.2	50.1
93	78.0	50.6
94	78.9	51.2
95	79.7	51.7
96	80.5	52.2
97	81.4	52.8
98	82.2	53.3
99	83.1	53.9
100	83.9	54.5
200	167.7	108.9
300	251.6	163.4
Dist.	Dep.	Lat.
	57 Deg.	

Diff.	34 Deg. Lat.	Dep
1	.8	.6
2	1.7	1.1
3	2.5	1.7
4	3.3	2.2
5	4.1	2.8
6	5.0	3.4
7	5.8	3.9
8	6.6	4.5
9	7.5	5.0
10	8.3	5.6
11	9.1	6.1
12	9.9	6.7
13	10.8	7.3
14	11.6	7.8
15	12.4	8.4
16	13.3	8.9
17	14.1	9.5
18	14.9	10.1
19	15.8	10.6
20	16.6	11.1
21	17.4	11.7
22	18.2	12.3
23	19.1	12.9
24	19.9	13.4
25	20.7	14.0
26	21.6	14.5
27	22.4	15.1
28	23.2	15.7
29	24.0	16.2
30	24.9	16.8
31	25.7	17.3
32	26.5	17.9
33	27.4	18.4
34	28.2	19.0
Diff.	Dep	Lat.
	56 Deg.	

Diff.	34 Deg. Lat.	Dep
35	29.0	19.6
36	29.8	20.1
37	30.7	20.7
38	31.5	21.2
39	32.3	21.8
40	33.2	22.4
41	34.0	22.9
42	34.8	23.5
43	35.6	24.0
44	36.5	24.6
45	37.3	25.1
46	38.2	25.7
47	39.0	26.3
48	39.8	26.8
49	40.6	27.4
50	41.4	28.0
51	42.3	28.5
52	43.1	29.1
53	43.9	29.6
54	44.8	30.2
55	45.6	30.7
56	46 4	31.3
57	47.3	31.9
58	48.1	32.4
59	48.9	33.0
60	49 7	33.5
61	50.6	34.1
62	51.4	34.6
63	52.2	35.2
64	53.0	35.8
65	53.9	36.3
66	54.7	36.9
67	55.5	37.4
68	56.4	38.0
Diff.	Dep	Lat.
	56 Deg.	

Diff.	34 Deg Lat.	Dep.
69	57.2	38.5
70	58.0	39.1
71	58.8	39.7
72	59.7	40.3
73	60.5	40.8
74	61.3	41.4
75	62.2	41.9
76	63 0	42.5
77	63.8	43.1
78	64.7	43.6
79	65.5	44.2
80	66.3	44.7
81	67.1	45.3
82	68.0	45.8
83	68.8	46.4
84	69.6	47.0
85	70.5	47.5
86	71.3	48.1
87	72.1	48.6
88	72.9	49.2
89	73.8	49.8
90	74.6	50.3
91	75.4	50.9
92	76.3	51.4
93	77.1	52.0
94	77.9	52.6
95	78.8	53.1
96	79.6	53.7
97	80.4	54.2
98	81.2	54.8
99	82.1	55.4
100	82.9	55.9
200	165.8	111.8
300	248.7	167.8
Diff.	Dep.	Lat.
	56 Deg.	

Dist.	35 Deg. Lat.	Dep.
1	.8	.6
2	1.7	1.1
3	2.5	1.7
4	3.3	2.3
5	4.1	2.9
6	4.9	3.4
7	5.7	4.0
8	6.6	4.6
9	7.4	5.2
10	8.2	5.7
11	9.0	6.3
12	9.8	6.9
13	10.6	7.5
14	11.5	8.0
15	12.3	8.6
16	13.1	9.2
17	13.9	9.8
18	14.7	10.3
19	15.6	10.9
20	16.4	11.5
21	17.2	12.0
22	18.0	12.6
23	18.8	13.2
24	19.6	13.8
25	20.5	14.3
26	21.3	14.9
27	22.1	15.5
28	22.9	16.1
29	23.7	16.6
30	24.6	17.2
31	25.4	17.8
32	26.2	18.4
33	27.0	18.9
34	27.8	19.5
Dist.	Dep.	Lat.
	55 Deg.	

Dist.	35 Deg. Lat.	Dep
35	28.6	20.1
36	29.5	20.6
37	30.3	21.2
38	31.1	21.8
39	31.9	22.4
40	32.8	22.9
41	33.6	23.5
42	34.4	24.1
43	35.2	24 6
44	36.0	25.2
45	36.8	25.8
46	37.7	26.4
47	38.5	27.0
48	39.3	27.5
49	40.1	28.1
50	41.0	28.7
51	41.8	29.2
52	42.6	29.8
53	43.4	30.4
54	44.2	31.0
55	45.1	31.5
56	45.9	32.1
57	46 7	32.7
58	47.5	33.3
59	48.3	33.8
60	49 1	34.4
61	50.0	35.0
62	50.8	35.6
63	51.6	36.1
64	52.4	36.7
65	53.3	37.3
66	54.1	37.9
67	54.9	38.4
68	55.7	39.0
Dist.	Dep	Lat.
	55 Deg.	

Dist.	35 Deg. Lat.	Dep.
69	56.5	39.6
70	57.3	40.2
71	58.2	40.7
72	59 0	41.3
73	59.8	41.9
74	60.6	42.5
75	61.5	43.0
76	62.3	43.6
77	63 1	44.2
78	63.9	44.8
79	64.7	45.3
80	65.5	45.9
81	66.4	46.5
82	67.2	47.0
83	68.0	47.6
84	68.8	48.2
85	69.6	48.8
86	70.5	49.3
87	71.3	49.9
88	72.1	50.5
89	72.9	51.1
90	73.7	51.6
91	74.6	52.2
92	75.4	52.8
93	76.2	53.4
94	77 0	53.9
95	77.8	54.5
96	78.6	55.1
97	79.5	55.6
98	80.3	56.2
99	81.1	56.8
100	81.9	57.4
200	163.8	114.7
300	245.8	172.1
Dist.	Dep.	Lat.
	55 Deg.	

Dist.	36 Deg. Lat.	Dep
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.2	2.3
5	4.0	2.9
6	4.8	3.5
7	5.7	4.1
8	6.5	4.7
9	7.2	5.3
10	8.1	5.9
11	8.9	6.5
12	9.7	7.0
13	10.5	7.6
14	11.3	8.2
15	12.1	8.8
16	12.9	9.4
17	13.8	10.0
18	14.6	10.6
19	15.4	11.2
20	16.2	11.8
21	17.0	12.3
22	17.8	12.9
23	18.6	13.5
24	19.4	14.1
25	20.2	14.7
26	21.0	15.3
27	21.8	15.9
28	22.6	16.4
29	23.5	17.0
30	24.3	17.6
31	25.1	18.2
32	25.9	18.8
33	26.7	19.4
34	27.5	20.0
Dist.	Dep	Lat.
	54 Deg.	

Dist.	36 Deg Lat	Dep
35	28.3	20.6
36	29.1	21.1
37	29.9	21.7
38	30.7	22.3
39	31.5	22.9
40	32.4	23.5
41	33.2	24.1
42	34.0	24.7
43	34.8	25.3
44	35.6	25.8
45	36.4	26.4
46	37.2	27.0
47	38.0	27.6
48	38.8	28.2
49	39.6	28.8
50	40.4	29.4
51	41.3	30.0
52	42.1	30.6
53	42.9	31.1
54	43.7	31.7
55	44.5	32.3
56	45.3	32.9
57	46.1	33.5
58	46.9	34.1
59	47.7	34.7
60	48.5	35.3
61	49.3	35.8
62	50.2	36.4
63	51.0	37.0
64	51.8	37.6
65	52.6	38.2
66	53.4	38.8
67	54.2	39.4
68	55.0	40.0
Dist.	Dep	Lat.
	54 Deg	

Dist.	36 Deg. Lat	Dep.
69	55.8	40.6
70	56.6	41.1
71	57.4	41.7
72	58.2	42.3
73	59.0	42.9
74	59.9	43.5
75	60.7	44.1
76	61.5	44.7
77	62.3	45.3
78	63.1	45.8
79	63.9	46.4
80	64.7	47.0
81	65.5	47.6
82	66.3	48.2
83	67.1	48.8
84	68.0	49.4
85	68.8	50.0
86	69.6	50.6
87	70.4	51.1
88	71.2	51.7
89	72.0	52.3
90	72.8	52.9
91	73.6	53.5
92	74.4	54.1
93	75.2	54.7
94	76.0	55.3
95	76.8	55.8
96	77.7	56.4
97	78.5	57.0
98	79.3	57.6
99	80.1	58.2
100	80.9	58.8
200	161.8	117.6
300	242.7	176.3
Dist.	Dep	Lat.
	54 Deg.	

Dist.	37 Deg. Lat.	Dep
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.2	2.4
5	4.0	3.0
6	4.8	3.6
7	5.6	4.2
8	6.4	4.8
9	7.2	5.4
10	8.0	6.0
11	8.8	6.6
12	9.6	7.2
13	10.4	7.8
14	11.2	8.4
15	12.0	9.0
16	12.8	9.6
17	13.6	10.2
18	14.4	10.8
19	15.2	11.4
20	16.0	12.0
21	16.8	12.6
22	17.6	13.2
23	18.4	13.8
24	19.2	14.4
25	20.0	15.0
26	20.8	15.6
27	21.6	16.2
28	22.4	16.8
29	23.2	17.4
30	24.0	18.0
31	24.8	18.6
32	25.6	19.2
33	26.4	19.8
34	27.1	20.4
Dist.	Dep	Lat.
	53 Deg	

Dist.	37 Deg Lat	Dep
35	27.9	21.0
36	28.7	21.6
37	29.5	22.2
38	30.3	22.8
39	31.1	23.4
40	31.9	24.1
41	32.7	24.7
42	33.5	25.3
43	34.3	25.9
44	35.1	26.5
45	35.9	27.1
46	36.7	27.7
47	37.5	28.3
48	38.3	28.9
49	39.1	29.5
50	39.9	30.1
51	40.7	30.7
52	41.5	31.3
53	42.3	31.9
54	43.1	32.5
55	43.9	33.1
56	44.7	33.7
57	45.5	34.3
58	46.3	34.9
59	47.1	35.5
60	47.9	36.1
61	48.7	36.7
62	49.5	37.3
63	50.3	37.9
64	51.1	38.5
65	51.9	39.1
66	52.7	39.7
67	53.5	40.3
68	54.3	40.9
Dist	Dep	Lat.
	53 Deg	

Dist.	37 Deg. Lat	Dep.
69	55.1	41.5
70	55.9	42.1
71	56.7	42.7
72	57.5	43.3
73	58.3	43.9
74	59.1	44.5
75	59.9	45.1
76	60.7	45.7
77	61.5	46.3
78	62.3	46.9
79	63.1	47.5
80	63.9	48.1
81	64.7	48.7
82	65.5	49.3
83	66.3	50.0
84	67.1	50.6
85	67.9	51.2
86	68.7	51.8
87	69.5	52.4
88	70.3	53.0
89	71.1	53.6
90	71.9	54.2
91	72.7	54.8
92	73.5	55.4
93	74.3	56.0
94	75.1	56.6
95	75.9	57.2
96	76.7	57.8
97	77.5	58.4
98	78.3	59.0
99	79.1	59.6
100	79.9	60.2
200	159.7	120.4
300	239.6	180.5
Dist.	Dep	Lat.
	53 Deg.	

Dist.	38 Deg. Lat.	Dep
1	.8	.6
2	1.6	1.2
3	2.4	1.8
4	3.1	2.5
5	3.9	3.1
6	4.8	3.7
7	5.5	4.3
8	6.3	4.9
9	7.1	5.5
10	7.9	6.2
11	8.7	6.8
12	9.5	7.4
13	10 2	8.0
14	11 0	8.6
15	11.8	9.2
16	12.6	9.9
17	13.4	10.5
18	14.2	11.1
19	15.0	11.7
20	15.8	12.3
21	16.6	12 9
22	17.3	13 6
23	18.1	14.2
24	18.9	14.8
25	19.7	15.4
26	20.5	16.0
27	21.3	16.6
28	22.1	17.2
29	22.9	17 9
30	23.6	18.5
31	24.4	19.1
32	25.2	19.7
33	26.0	20 3
34	26.8	20.9
Dist.	Dep	Lat.
	52 Deg.	

Dist.	38 Deg. Lat.	Dep
35	27.6	21.6
36	28.4	22.2
37	29.2	22.8
38	29.9	23.4
39	30.7	24.0
40	31.5	24.6
41	32.3	25.2
42	33 1	25.9
43	33.9	26.5
44	34.7	27.1
45	35.5	27.7
46	36.2	28.3
47	37.0	28.9
48	37.8	29.6
49	38 6	30.2
50	39.4	30.8
51	40.2	31.4
52	41.0	32.0
53	41 8	32.6
54	42.6	33.2
55	43.3	33 9
56	44.1	34.5
57	44.9	35.1
58	45.7	35.7
59	46.5	36.3
60	47.3	36.9
61	48.1	37.6
62	48.9	38.2
63	49.6	38.8
64	50.4	39 4
65	51.2	40.0
66	52.0	40.6
67	52.8	41.2
68	53 6	41.9
Dist.	Dep	Lat.
	52 Deg.	

Dist.	38 Deg. Lat.	Dep.
69	54.4	42.5
70	55.2	43 1
71	55.9	43.7
72	56.7	44.3
73	57.5	45.0
74	58.3	45.6
75	59.1	46.2
76	59.9	46.8
77	60.7	47.4
78	61.5	48.0
79	62.2	48.6
80	63.0	49 3
81	63.8	49 9
82	64.6	50.5
83	65.4	51.1
84	66.2	51.7
85	67.0	52.3
86	67.8	53.0
87	68.6	53.6
88	69.3	54.2
89	70.1	54.8
90	70.9	55.4
91	71.7	56.0
92	72.5	56.6
93	73.3	57.3
94	74.1	57.9
95	74.9	58.5
96	75.6	59.1
97	76.4	59.7
98	77.2	60.3
99	78.0	61.0
100	78.8	61.6
200	157 6	123.1
300	236.4	284.7
Dist	Dep.	Lat.
	52 Deg.	

Dist.	39 Deg. Lat.	Dep
1	.8	.6
2	1.6	1.3
3	2.3	1.9
4	3.1	2.5
5	3.9	3.1
6	4.7	3.8
7	5.4	4.4
8	6.1	5.0
9	7.0	5.7
10	7.8	6.3
11	8.5	6.9
12	9.3	7.5
13	10.1	8.2
14	10.9	8.8
15	11.6	9.4
16	12.4	10.1
17	13.2	10.7
18	14.0	11.3
19	14.8	11.9
20	15.5	12.6
21	16.3	13.2
22	17.1	13.8
23	17.9	14.5
24	18.6	15.1
25	19.4	15.7
26	20.2	16.4
27	21.0	17.0
28	21.7	17.6
29	22.5	18.2
30	23.3	18.9
31	24.1	19.5
32	24.9	20.1
33	25.6	20.8
34	26.4	21.4
Dist.	Dep	Lat.
	51 Deg.	

Dist.	39 Deg. Lat.	Dep
35	27.2	22.0
36	28.0	22.6
37	28.7	23.3
38	29.5	23.9
39	30.3	24.5
40	31.1	25.2
41	31.8	25.8
42	32.6	26.4
43	33.4	27.1
44	34.2	27.7
45	35.0	28.3
46	35.7	28.9
47	36.5	29.6
48	37.3	30.2
49	38.1	30.8
50	38.8	31.5
51	39.6	32.1
52	40.4	32.7
53	41.2	33.4
54	41.9	34.0
55	42.7	34.6
56	43.5	35.2
57	44.3	35.9
58	45.1	36.5
59	45.8	37.1
60	46.6	37.8
61	47.4	38.4
62	48.2	39.0
63	48.9	39.6
64	49.7	40.3
65	50.5	40.9
66	51.3	41.5
67	52.1	42.2
68	52.8	42.8
Dist.	Dep	Lat.
	51 Deg.	

Dist.	39 Deg. Lat.	Dep.
69	53.6	43.4
70	54.3	44.0
71	55.2	44.7
72	55.9	45.3
73	56.7	45.9
74	57.5	46.6
75	58.3	47.2
76	59.1	47.8
77	59.8	48.5
78	60.6	49.1
79	61.4	49.7
80	62.2	50.3
81	62.9	51.0
82	63.7	51.6
83	64.5	52.2
84	65.3	52.9
85	66.1	53.5
86	66.8	54.1
87	67.6	54.7
88	68.4	55.4
89	69.2	56.0
90	69.9	56.6
91	70.7	57.3
92	71.5	57.9
93	72.3	58.5
94	73.1	59.1
95	73.8	59.8
96	74.6	60.4
97	75.4	61.0
98	76.2	61.7
99	76.9	62.3
100	77.7	62.9
200	155.4	125.9
300	233.1	233.8
Dist.	Dep.	Lat.
	51 Deg.	

Dist.	40 Deg. Lat.	Dep.
1	.8	.6
2	1.5	1.3
3	2.3	1.9
4	3.1	2.6
5	3.8	3.2
6	4.6	3.8
7	5.4	4.5
8	6.4	5.1
9	6.9	5.8
10	7.7	6.4
11	8.4	7.1
12	9.2	7.7
13	10.0	8.3
14	10.7	9.0
15	11.5	9.6
16	12.3	10.3
17	13.0	10.9
18	13.8	11.6
19	14.6	12.2
20	15.3	12.9
21	16.1	13.5
22	16.9	14.1
23	17.6	14.8
24	18.4	15.4
25	19.2	16.1
26	19.9	16.7
27	20.7	17.3
28	21.4	18.0
29	22.2	18.6
30	23.0	19.3
31	23.7	19.9
32	24.5	20.6
33	25.3	21.2
34	26.0	21.9
Dist.	Dep	Lat.
	50 Deg.	

Dist.	40 Deg. Lat.	Dep
35	26.8	22.5
36	27.6	23.1
37	28.3	23.8
38	29.1	24.4
39	29.9	25.1
40	30.6	25.7
41	31.4	26.3
42	32.2	27.0
43	32.9	27.6
44	33.7	28.3
45	34.5	28.9
46	35.2	29.6
47	36.0	30.2
48	36.8	30.9
49	37.5	31.5
50	38.3	32.1
51	39.1	32.8
52	39.8	33.4
53	40.6	34.1
54	41.4	34.7
55	42.1	35.3
56	42.9	36.0
57	43.7	36.6
58	44.4	37.3
59	45.2	37.9
60	46.0	38.6
61	46.7	39.2
62	47.5	39.9
63	48.3	40.5
64	49.0	41.1
65	49.8	41.8
66	50.6	42.4
67	51.3	43.1
68	52.1	43.7
Dist.	Dep	Lat.
	50 Deg.	

Dist.	40 Deg. Lat.	Dep.
69	52.9	44.3
70	53.6	45.0
71	54.4	45.6
72	55.2	46.3
73	55.9	46.9
74	56.7	47.6
75	57.4	48 2
76	58.2	48.7
77	59.0	49.5
88	59.7	50.1
79	60.5	50.8
80	61.3	51.4
81	62.0	52.1
82	62.8	52.7
83	63.6	53.3
84	64.3	54.0
85	65.1	54.6
86	65.9	55.3
87	66.6	55 9
88	67.4	56.6
89	68.2	57.2
90	68.9	57.9
91	69.7	58.5
92	70.5	59.1
93	71.2	59.8
94	72.0	60.4
95	72.7	61.1
96	73.5	61.7
97	74.3	62.3
98	75.1	63.0
99	75.8	63.6
100	76.6	64.3
200	153.2	128.0
300	229.8	192.8
Dist.	Dep.	Lat.
	50 Deg.	

Dist.	41 Deg. Lat.	Dep.
1	.8	.7
2	1.5	1.3
3	2.3	2.0
4	3.0	2.6
5	3.8	3.3
6	4.5	3.9
7	5.3	4.6
8	6.0	5.2
9	6.8	5.9
10	7.5	6.6
11	8.3	7.2
12	9.0	7.9
13	9.8	8.5
14	10.6	9.0
15	11.3	9.8
16	12.1	10.5
17	12.8	11.2
18	13.6	11.8
19	14.3	12.5
20	15.1	13.1
21	15.9	13.8
22	16.6	14.4
23	17.4	15.1
24	18.1	15.7
25	18.9	16.4
26	19.6	17.1
27	20.4	17.7
28	21.1	18.4
29	21.9	19.0
30	22.6	19.7
31	23.4	20.3
32	24.1	21.0
33	24.9	21.6
34	25.7	22.3
Dist.	Dep	Lat.

49 Deg.

Dist.	41 Deg. Lat.	Dep
35	26.4	23.9
36	27.2	23.6
37	27.9	24.3
38	28.7	24.9
39	29.4	25.6
40	30.2	26.2
41	30.9	26.9
42	31.7	27.5
43	32.4	28.2
44	33.2	28.9
45	33.9	29.5
46	34.7	30.2
47	35.4	30.8
48	36.2	31.5
49	36.9	32.1
50	37.7	32.8
51	38.5	33.4
52	39.2	34.1
53	40.0	34.8
54	40.7	35.4
55	41.5	36.1
56	42.2	36.7
57	43.0	37.4
58	43.8	38 0
59	44.5	38.7
60	45.3	39 4
61	46.0	40.0
62	46.8	40.7
63	47.5	41.3
64	48.3	42.0
65	49.0	43.6
66	49.8	43.3
67	50.6	44.9
68	51.3	44.6
Dist.	Dep	Lat.

49 Deg.

Dist.	41 Deg. Lat.	Dep.
69	52.1	45.2
70	52.8	45.8
71	53.6	46.6
72	54.3	47.2
73	55.1	47.8
74	55.8	48.5
75	56.6	49.2
76	57.4	49.8
77	58 1	50.5
78	58.9	51.2
79	59.6	51.8
80	60.4	52.5
81	61.1	53.1
82	61.9	53.8
83	62.6	54.4
84	63.4	55.1
85	64.1	557
86	64.9	56.4
87	65.6	57.1
88	66.4	57 7
89	67.1	58.4
90	67.9	59.0
91	68.7	59.7
92	69.4	60.3
93	70.2	61.0
94	70.9	61.6
95	71.7	62.3
96	72.4	62.9
97	73.2	63.6
98	73.9	643
99	74.7	64.9
100	75.5	65.6
200	150.9	131.2
300	226.4	196.8
Dist.	Dep.	Lat.

49 Deg.

Dist.	42 Deg. Lat.	Dep.
1	·7	·7
2	1.5	1.3
3	2.2	2.0
4	3.0	2.7
5	3.7	3.3
6	4.4	4.0
7	5.2	4 7
8	5 9	5.3
9	6.7	6.0
10	7.4	6.7
11	8.2	7.3
12	8.9	8.0
13	9.7	8.7
14	10.4	9.3
15	11.1	10.0
16	11.9	10.7
17	12 6	11 3
18	13.4	12 0
19	14.1	12 7
20	14.9	13.4
21	15.6	14.0
22	16.3	14 7
23	17.1	15 4
24	17.8	16.0
25	18.6	16.7
26	19.3	17.4
27	20.1	18.0
28	20.8	18 7
29	21.5	19.4
30	22.3	20.1
31	23.0	22 4
32	23.8	23.4
33	24.5	24.1
34	25.3	25 7
Dist.	Dep.	Lat.
	48 Deg.	

Dist.	42 Deg. Lat.	Dep
35	26.0	23.4
36	26.7	24.1
37	27.5	24 7
38	28.2	25.1
39	29.0	26.4
40	2.97	26.8
41	30.4	27 4
42	31.2	28.1
43	31.9	28.7
44	32.7	29.4
45	33.4	30 1
46	34.2	30.8
47	34.9	31.4
48	35.7	32.1
49	36.4	32.8
50	37.2	33.5
51	37 9	34.1
52	38.6	34.8
53	39.4	35.4
54	40.1	36.1
55	40 9	36.8
56	41.6	37.5
57	42.3	38.1
58	43.1	38.8
59	43.8	39.4
60	44.6	40.1
61	45.3	40.8
62	46.1	41.5
63	46.8	42.1
64	47.5	42.8
65	48.3	43.5
66	49.0	44.2
67	49 8	44.8
68	50.5	45.5
Dist.	Dep	Lat.
	48 Deg	

Dist.	42 Deg. Lat.	Dep.
69	51.3	46,2
70	52.0	46.8
71	52.7	47.5
72	53.5	48.2
73	54.2	48 8
74	55 0	49 5
75	55.7	50.2
76	56.4	50.9
77	57 2	51.5
78	57.9	52.2
79	58.7	52.9
80	59.4	53.5
81	60.2	54.2
82	60.9	54.9
83	61.7	55.5
84	62.4	56 2
85	63 2	56.9
86	63.9	57.5
87	64.7	58.2
88	65.4	58.9
89	66.1	59.5
90	66.9	60.2
91	67.6	60.9
92	68.4	61.5
93	69.1	62.2
94	69.9	62.9
95	70.6	63.5
96	71.3	64.2
97	72.1	64.9
98	72.8	65.5
99	73.6	66.2
100	74.4	66,9
200	248.6	213.8
300	342.9	340.7
Dist.	Dep.	Lat.
	48 Deg.	

Dist.	43 Deg. Lat.	Dep.
1	.7	.7
2	1.5	1.4
3	2.2	2.0
4	2.9	2.7
5	3.6	3.4
6	4.4	4.1
7	5.1	4.8
8	5.8	5.4
9	6.6	6.1
10	7.3	6.8
11	8.0	7.5
12	8.8	8.2
13	9.5	8.9
14	10.2	9.5
15	10.9	10.2
16	11.7	10.9
17	12.4	11.6
18	13.2	12.3
19	13.9	13.0
20	14.6	13.6
21	15.3	14.3
22	16.1	15.0
23	16.8	15.7
24	17.5	16.4
25	18.3	17.0
26	19.0	17.7
27	19.7	18.4
28	20.5	19.1
29	21.2	19.8
30	21.9	20.5
31	22.7	21.1
32	23.4	21.8
33	24.1	22.5
34	24.8	23.0
Dist.	Dep.	Lat.
	47 Deg	

Dist.	43 Deg Lat.	Dep
35	25.6	23.9
36	26.3	24.5
37	27.0	25.2
38	27.8	25.9
39	28.5	26.6
40	29.2	27.3
41	30.0	28.0
42	30.7	28.6
43	31.4	29.3
44	32.2	30.0
45	32.9	30.7
46	33.6	31.4
47	34.4	32.0
48	35.1	32.7
49	35.8	33.4
50	36.6	34.1
51	37.3	34.8
52	38.0	35.5
53	38.8	36.1
54	39.5	36.8
55	40.2	37.5
56	40.9	38.2
57	41.7	38.9
58	42.4	39.5
59	43.1	40.2
60	43.9	40.9
61	44.6	41.6
62	45.3	42.3
63	46.1	43.0
64	46.8	43.6
65	47.5	44.3
66	48.3	45.0
67	49.0	45.7
68	49.7	46.4
Dist.	Dep	Lat.
	47 Deg	

Dist.	43 Deg. Lat.	Dep.
69	50.5	47,0
70	51.2	47.7
71	51.9	48.4
72	52.6	49.1
73	53.4	49 8
74	54.1	50.5
75	54.8	51.1
76	55.6	51.8
77	56 3	52.5
78	57.0	53.2
79	57.8	53.9
80	58.5	54.6
81	59.2	55.2
82	60.0	55.9
83	60.7	56.6
84	61.4	57.3
85	62.2	58.0
86	62.9	58.7
87	63.6	59.3
88	64.3	60.0
89	65.1	60.7
90	65.8	61.4
91	66.5	62.1
92	67.3	62.7
93	68.0	63.4
94	68.7	64.1
95	69.5	64.8
96	70.2	65.5
97	70.9	66.1
98	71.7	66.8
99	72.4	67.5
100	73.1	68,2
200	146.3	136.4
300	219.4	204.6
Dist.	Dep.	Lat.
	47 Deg	

Dist.	44 Deg Lat	Dep
1	.7	.7
2	1.4	1.4
3	2 2	2.1
4	2.9	2.8
5	3.6	3.5
6	4.3	4 2
7	5.0	4.9
8	5.8	5.6
9	6.5	6.2
10	7.2	6.9
11	7 9	7.6
12	8.6	8.3
13	9.3	9.0
14	10 1	9.7
15	10.8	10.4
16	11.5	11.1
17	12.2	11.8
18	12 9	12.5
19	13 7	13.2
20	14.4	13 9
21	15 1	14.6
22	15.8	15.3
23	16.5	16.0
24	17.3	16.7
25	18.0	17.4
26	18.7	18 1
27	19.4	18.8
28	20.1	19.5
29	20.9	20 1
30	21.6	20.8
31	22.3	21.5
32	23.0	22.2
33	23.7	22.9
34	24.5	23.6
Dist.	Dep	Lat

46 Deg.

Dist.	44 Deg Lat	Dep
35	25.1	24.3
36	25.9	25.0
37	26.6	25.7
38	27.3	26.4
39	28.0	27.1
40	28.8	27.8
41	29.5	28.5
42	30.2	29.2
43	30.9	29.9
44	31.6	30.6
45	32 4	31.3
46	33.1	32.0
47	33.8	32.7
48	34.5	33.4
49	35.2	34.0
50	36.0	34.7
51	36.7	35 4
52	37.4	36.1
53	38.1	36.8
54	38.8	37.5
55	39 6	38.2
56	40.3	38.9
57	41.0	39.6
58	41.7	40.3
59	42.4	41.0
60	43.2	41.7
61	43.9	42.4
62	44.6	43.1
63	45.3	43.8
64	46.0	44 5
65	46.8	45.2
66	47.5	45.8
67	48.2	46.5
68	48.0	47.2
Dist.	Dep	Lat

46 Deg

Dist.	44 Deg Lat	Dep
69	49 6	47.9
70	50.3	48.6
71	51.1	49.3
72	51.8	50.0
73	52.5	50.7
74	53.2	51.4
75	53.9	52.1
76	54 7	52.8
77	55.4	53.5
78	56.1	54.2
79	56.8	54.9
80	57 5	55.6
81	58.3	56.3
82	59.0	57.0
83	59.7	57.7
84	60.4	58.4
85	61 1	59.0
86	61.9	59 7
87	62.6	60.4
88	63.3	61.1
89	64.0	61.8
90	64 7	62.5
91	65.5	63.2
92	66.2	63.9
93	66.9	64.6
94	67.6	65.3
95	68.3	66.0
96	69.0	66.7
97	69.8	67.4
98	70.5	68.1
99	71.2	68.8
100	71.9	69.5
200	143.9	138.9
300	215.8	208.4
Dist.	Dep	Lat

46 Deg

Dist	45 Deg Lat	Dep
1	.7	.7
2	1.4	1.4
3	2.1	2.1
4	2.8	2.8
5	3.5	3.5
6	4.2	4.2
7	4.9	4.9
8	5.6	5.6
9	6.4	6.4
10	7.1	7.1
11	7.8	7.8
12	8.5	8.5
13	9.2	9.2
14	9.9	9.9
15	10.6	10.6
16	11.3	11.3
17	12.0	12.0
18	12.7	12.7
19	13.4	13.4
20	14.1	14.1
21	14.8	14.8
22	15.5	15.5
23	16.3	16.3
24	17.0	17.0
25	17.7	17.7
26	18.4	18.4
27	19.1	19.1
28	19.8	19.8
29	20.5	20.5
30	21.2	21.2
31	21.9	21.9
32	22.6	22.6
33	23.3	23.3
34	24.0	24.0
Dist	Dep	Lat
	45 Deg	

Dist	45 Deg Lat	Dep
35	24.7	24.7
36	25.4	25.4
37	26.1	26.1
38	26.8	26.8
39	27.5	27.5
40	28.3	28.3
41	29.0	29.0
42	29.7	29.7
43	30.4	30.4
44	31.1	31.1
45	31.8	31.8
46	32.5	32.5
47	33.2	33.2
48	33.9	33.9
49	34.6	34.6
50	35.3	35.3
51	36.0	36.0
52	36.7	36.7
53	37.5	37.5
54	38.2	38.2
55	38.9	38.9
56	39.6	39.6
57	40.3	40.3
58	41.0	41.0
59	41.7	41.7
60	42.4	42.4
61	43.1	43.1
62	43.8	43.8
63	44.5	44.5
64	45.2	45.2
65	45.9	45.9
66	46.6	46.6
67	47.4	47.4
68	48.1	48.1
Dist	Dep	Lat
	45	Deg

Dist	45 Deg Lat	Dep
69	48.8	48.8
70	59.5	49.5
71	50.2	50.2
72	50.9	50.9
73	51.6	51.6
74	52.3	52.3
75	53.0	53.0
76	53.7	53.7
77	54.4	54.4
78	55.1	55.1
79	55.8	55.8
80	56.6	56.6
81	57.3	57.3
82	58.0	58.0
83	58.7	58.7
84	59.4	59.4
85	60.1	60.1
86	60.8	60.8
87	61.5	61.5
88	62.2	62.2
89	62.9	62.9
90	63.6	63.6
91	64.3	64.3
92	65.0	65.0
93	65.7	65.7
94	66.5	66.5
95	67.2	67.2
96	67.8	67.8
97	68.6	68.6
98	69.3	69.3
99	70.0	70.0
100	70.7	70.7
200	141.4	141.4
300	212.1	212.1
Dist	Dep	Lat
	45	Deg

Rule, Turn the Compaſs ſo that the Courſe ſteered may point from you, then if the Variation be Weſterly it muſt be reckoned from the Courſe ſteered towards the Left Hand, and then you have the Courſe made good, but if the Variation be Eaſterly, you muſt reckon the Variation, from the Courſe ſteered towards the Right-Hand, and you have the Courſe made good.

Example, Suppoſe a Ship ſteers N. W. by a Compaſs that has a Point Weſterly Variation, then I ſay ſhe makes her way good, N. W. by W. for the Compaſs being placed ſo that the N. W. Point may Point from you, and then reckoning one point, *viz.* the Variation towards the Left-Hand, you will come to the N. W. by W. which is the Courſe made good, if the Variation had been one point Eaſterly the Courſe made good had been N. W. by W. that is a point to the Right-hand, of the Courſe ſteered, and ſo the Courſe made good, may be found by help of the Courſe ſteered, and the Variation in any other caſe whatſoever.

CHAP. VII. *Certain Problems touching Currents.*

ALthough the Time be already expired which I aſſigned for this Work, and mine own more urgent Occaſions call me away, yet ſeeing it is neceſſary in *Navigation* to take Notice of Currents, and to make a competent Allowance for them; I will briefly ſet down certain *Problems*, ſuch as I have ſometimes thought upon, whereby a Man may the better conceive and judge of that Allowance, the rather, for that I know not any that have handled it.

Firſt then, it is to be conceived, that a Ship, or other Veſſel, ſailing or rowing where there is a Current, hath a Compound Motion ariſing of two different Principles; namely, of the Current, and Ship's way: So that here are three Motions to be conſidered; namely, two ſimple, and the third compound of of them. The firſt ſimple Motion is that of the Current, whereby it moveth, and is apt to move other things that are in it the ſame way. The ſecond of the Ship or Boat, as it moveth by Wind or Oars, or is apt to be moved if there were no Current. The third, Compound of them, is the Line of the Ship's true Motion. The firſt, We call the Way or Motion of the Current; the ſecond, the Way or ſimple Motion of the Ship; the third, her Compound or true Way, the two ſimple Motions being either of them according to the right Lines, and uniform, as in the *Problems* following we ſuppoſe them to be. The third alſo which is compoſed of them is a right Line, for whether the Ship ſails directly oppoſite againſt the Currents, or directly with it the ſame way, or whether the one croſs the other at Right Angles, or at Oblique; yet ſtill either Motion being direct and uniform, they both together beget a Right-lin'd uniform'd Motion, becauſe the one retaineth to the other, one and the ſame proportion in every Point: And according to theſe Grounds we proceed in the *Problems* following, to determine the Proportions of every of theſe Motions, and the Angles they make one with another.

1. *Admit a Current run Eaſt 3 Miles an Hour, and that a Ship under Sail run Weſt directly againſt it 6 Miles an Hour in her ſimple Motion, What is her true or Compound Motion?*

From the Ship's ſimple Motion —— 6 miles.
Subtract the Current —— 3 miles.
The Remainder is the Ship's true Motion —— 3 miles.

So

So the Ship's true Way is to the Weſtward 3 miles an Hour.

2. *Admit a Current runs Weſt 6 miles an Hour, and that a Ship under Sail run directly againſt it 5 Miles an Hour by the Log. What is the Ship's Compound Motion, and which way?*

From the Current, being the greater ——— 6 miles,
Subtract the Ship's ſimple Motion ——— 5 miles,
There remains the Ship's true Motion ——— 1 mile.

Which 1 mile ſhews, that the Ship by her Compound Motion falls aſtern, that is, moves to the Weſtward 1 mile an Hour.

In the experimental Practice of the two former *Problems* it may ſeem, that a Ship or Boat ſo order'd, hath alſo a motion to the Right-hand or to the Left; but this comes to paſs, becauſe it is hard, and in a manner impoſſible to ſtem a Tide or Stream ſo exactly, but that the Ship will ſwerve (or yaw, as they ſay) either to one ſide or to the other.

3. *Admit a Current run Eaſt 3 miles an Hour, and that the Ship alſo run Eaſt 3 miles an Hour by the Log. What is the Ship's true Motion?*

To the Ship's ſimple Motion ——— 3 miles,
Add the Current ——— 3 miles,
The Sum is the Ship's true Motion ——— 6 miles.

So the Ship's Compound or true Way is Eaſt 6 miles.

4. *Admit a Current run Eaſt 2 miles an Hour, and the Ship South 6 miles an Hour: What is the Ship's true Motion, and which Way?*

In handling of any Art, to avoid Circumlocution, there are uſed Terms, or Words of Art, ſerving to expreſs briefly the things handled. And foraſmuch as this Subject hath not been formerly handled, nor the Principles or Grounds thereof laid (ſo far as I know) we will add a few ſuch Terms as may ſeem moſt neceſſary, expreſſing here what we mean by them. Let the Line AB run from A to the Southwards, and BD from B to the Eaſtwards; and let AB be in proportion to BD as 6 to 2, or 3 to 1.

Then doth AB repreſent the Line of the Ship's ſimple Motion, BD the Motion of the Current, and AD the Compounded Motion of the Ship.

And DAB is the Angle contained between the Line of the Ships's ſimple Motion and the Line of her Compound, or true Motion, which for Brevity ſake, we will henceforth call, *The Angle of Deflection.* Alſo ADB is the Angle contained between the Line of the Ship's compound Motion, and the Set or Drift of the Current, which we call the *Angle of Reflection.*

Laſtly, ABD, is the Angle contained between the Line of the Ship's ſimple Motion and the Set of the Current, which we call the *Angle of Incidence.*

Then for the Rhomb, the Proportion is thus.

As the ſimple Motion AB 6 miles — *Co. Ar.* — 9.221849
Is to the Current — BD 2 miles ——— 0.301030
So is the Radius ———
To the Tangent of the Deflections, DAB 18d.26m 9.522879

So

So the Rhomb upon which the Ship makes her way good is South 18 deg. 26 min. Easterly, that is S. S. E 4 deg. 4 min. Southerly.

2. *For the Ship's true Way, or Compound Motion.*

As the Sine of the Deflection *s.* DAB 18 deg. 26 min. —— 0.500037
To the Current. —— DB 2 Miles —— 0.301036
So is Radius ——
To the true Motion —— AD $6\frac{3}{100}$ —— 0.801067

So the Ship's compound Motion is $6\frac{3}{100}$, miles hourly, that is $6\frac{1}{4}$ miles almost.

5. *A Ship sails West 5 Days together, by the Log. 725 Miles: But there is a Current all this while setting to the Southward* $1\frac{1}{2}$ *Miles an Hour: I demand how she hath sailed, and how far?*

The Current setting $1\frac{1}{2}$ mile an Hour, sets in 5 Days 180 miles:
Therefore,

As the simple Motion —— AB 725 miles —— 7.139652
Is to the Current —— DB 180 miles —— 2.255272
So is Radius ——
To the Tangent of the Deflection *t.* —— DAB 13 deg. 57 min. —— 9.394934

For the Distance.

As Sine Compl. the Deflect *sc.* DAB 13 deg. 57 min. —— 0.013062
Is to the simple Motion —— AB 725 miles —— 2.860338
So is Radius ——
To the compound Motion —— AD 747 miles —— 2.873340

So the Ship's true Way is West Southerly 13 deg. 57 min. or South Westerly 76 deg 03 min. 747 miles.

6. *A Ship sails West 5 Days together by the Log. 725 Miles, in a Currents setting to the Southwards, and then finds that she hath altered her Latitude three Degrees; I demand the Motion of the Current, the true Rhomb, and true way of the Ship.*

This Question differeth little from the former; for seeing the difference of Latitude is 3 deg the Motion of the Current is 180 Miles; so there is given the Ship's simple Motion and the Motion of the Current as before, *&c.*

7. *A Ship in 6 hours sails from a certain Cape, or Headland South 30 miles by the Log. in a Current setting Easterly; and then observing the same Cape, he finds that it bears N.N.W. I demand how fast that Current sets, and how far she hath sailed?*

As let a Ship sail from A towards B South 30 Miles, but by means of the Current she is driven more Easterly, namely to D; from whence letting the Cape A, it is found to bear N. N. W. And seeing the Current sets from B towards D Easterly; therefore the Angle of Reflections BDA is 6 Points, that is, 67 deg. 30 min. Here then is demanded the Distance AD, and the drift of the Current in that time BD.

As the Sine of the Angle of Reflection *s.* BDA 67 d. 30 m. —— 0.34385
To the simple Motion of the Ship AB 30 miles —— 1.477121
So is the Sine of the Angle of Deflection *s.* DAB 22 d. 30 m. —— 9.582839
To the Motion of the Current BD $12\frac{16}{100}$ —— 1.094345

And

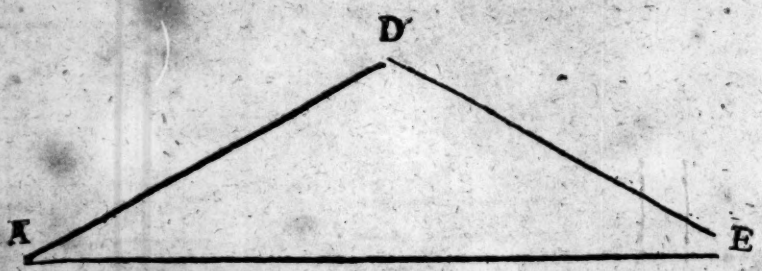
And further.

As the Sine of the Angle of Reflection *ſ.* BDA 67 d. 30 m. —— 0.34385
To the Diſtance run by the Log AB. 30 miles —— 1.477121
So is Radius
To the compound Motion of the Ship AD 32 $\frac{4}{5}\frac{7}{0}$ —— 1.511506

And thus we find that Current to ſet $12\frac{1}{1}\frac{6}{0}$, that is near $12\frac{1}{6}$ Miles in ſix Hours, and the Diſtance run to be $32\frac{1}{2}$ Miles almoſt.

That the Thing may be conceived, we will uſe two or three Examples more familiar and obvious to every Man's Experience, yet grounded upon the ſame Principles and Reaſons.

8. *Admit that* Tuly-ſtairs *bears from* Billinſgate-ſtairs *S. W. Southerly, namely, South Weſterly* 40 *Degrees, and be diſtant* 80 *Poles; and ſuppoſe the Tide of Ebb to run there Eaſtward* $2\frac{1}{2}$ *Miles an Hour, and that a Pair of Oars rowing* $4\frac{1}{2}$ *Miles an Hour would go ſtrait over from the firſt to the ſecond: How ſhall they row over; namely, upon what Degree or Point of the Compaſs, and how far ſhall they row to get thither, and in what time?*



Let A repreſent *Billinſgate-ſtairs*, D *Tuly-ſtairs*, AE the ſimple Motion of the Boat, ED the Motion of the Current; then is A the Angle of Deflection, E the Angle of Incidence, D the Angle of Deflection, 130 deg. or 50 deg. the Complement to 180 deg.

As the ſimple Motion of the Boat —— AE $4\frac{1}{2}$ miles —— 9.371612
Is to the Motion of the Tide —— DE $2\frac{1}{2}$ miles —— 0.397940
So is the Sine of Reflection —— Ds 50 deg. —— 9 8842 54
To the Sine of the Angle of Deflect. —— As 26 d. 47 m. —— 9.653806

Thus then the Poſition from A to D, being South Weſterly 40 deg and the Angle of Deflection A 26 deg. 47 min. the Poſition from A towards E, is South Weſterly 66 deg. 47 min. that is W S. W. Southerly: And ſo muſt thoſe Oars row to go ſtrait over.

Secondly, For the Diſtance AE.

From the Angle of Reflection —— D 50 deg. 00 min
Subtract the Angle of Deflection —— A 26 deg. 47 min
And there reſts the Angle of Incidence —— E 32 deg. 13 min
As the Sine of Incidence —— *ſ.* E. 23 deg. 13 min. —— 0.404274
To the true Diſtance —— AD 80 Poles —— 1 903090
So is the Sine of Deflection —— *ſ.* D 50 deg. 00 min. —— 9.8842 54
To the ſimple Motion —— AE 155 $\frac{4}{5}$ Poles —— 2.191618

Laſtly,

Laſtly, for the time,

Seeing 320 Poles make a Mile, and they row $4\frac{1}{2}$ Miles an Hour, it is 1440 Poles in an Hour; ſo the proportion is,

As the ſimple hourly Motion	1440	6.841638
To the ſimple Motion before found	$155\frac{4}{10}$	2.191451
So is an Hour in Minutes, namely	60 min.	1.778151
To the Time required in Minutes	$6\frac{47}{100}$	0.811280

And ſo long will they be rowing over.

9. *But ſo ſuppoſe they row harder to go a ſhorter Cut, namely, to go South Weſt by Weſt, how faſt muſt they row to go ſtrait over, and how far in what time?*

Then ſeeing the Poſition from A to D is South Weſterly 40 degrees, and South Weſt by Weſt is South Weſterly 56 deg. 15 min. therefore the Angle of Deflection at A, is 16 deg. 15 min. the Angle of Reflection D as before, 50 deg. 00 min. the Angle of Incidence E 33 deg. 45 min.

As the Sine of Deflection	ſ. A 16 deg. 15 min.	.553108
To the Motion of the Tide	DE $2\frac{1}{2}$ Miles	0.397940
So is the Sine of the Angle of Reflect. D	50 deg. 00 min.	9.884254
To the ſimple hourly Motion of the Boat AE	$6\frac{844}{1000}$	0.83539

And ſuch is the hourly Motion of the Boat, namely, $6\frac{844}{1000}$ miles in an Ho

Secondly for the ſimple Motion.

As the Sine of Incidence	ſ E 33 deg. 45 min.	255161
Is to the true Diſtance	AD 80 Poles	1.903090
So is the Sine of Reflection	D 50 deg. 00 min.	9.884254
To the ſimple Motion	AE $110\frac{3}{10}$ Poles	2,042605

Thus it appears they muſt row $110\frac{3}{10}$ Poles to get over.

Laſtly, for the Time.

The hourly Motion before found $6\frac{844}{1000}$ reduced into Poles, is		$2190\frac{5}{10}$
As the ſimple hourly Motion	2190	6.659556
Is in Proportion to an hour, or	60 min.	1.778151
So is the ſimple Motion before found	$110\frac{3}{10}$	2.042575
To the Time required	$3\frac{22}{1000}$	0.480282

And ſo long they will be rowing over.

10. *But admit a Sculler rowing 3 Miles an Hour, would croſs ſtrait over at the ſame time; upon what point muſt he row, and how far, to get thither, and in what time will he do it?*

First, for the Angle of Position.

As the hourly Motion of the Boat	AE 3 miles	9.522879
To the Sine of Reflection	D*ſ.* 50 deg.	9.884254
So is the hourly Motion of the Stream	DE $2\frac{1}{2}$ min.	0.397940
To the Sine of Deflection	A*ſ.* 39 deg. 40 min.	9.805073

Now ſeeing this Poſition from *Billinſgate* to *Tuly-Stairs*, namely, from A to D, is by ſuppoſition to the Weſtward of the South 40 deg. and the Angle of Deflection A is here found to be 39 deg. 40 min. therefore the Poſition from A to E is from the South to the Weſtward 79 deg. 40 min. which is W. and by S. and almoſt 1 deg. Weſterly, and ſo muſt that Sculler row to go ſtrait over.

Secondly, for the Diſtance AE.

		deg.	min.
From the Angle of Reflection	D	50	40
Subtract the Angle of Deflection	A	39	20
There reſts the Angle of Incidence	E	10	20
As the Sine of Incidence	*ſ.* E 10 deg. 20 min.		746230
To the true Diſtance	AD 80 Poles		1.903090
So the Sine of Reflection	*ſ.* D 50 deg. 00 min.		9.884257
To the ſimple Motion	AE 341 $\frac{6}{10}$ Poles		2.533574

And thus it appears, that though the Diſtance of the two Places be but 80 Poles, yet, if according to the Queſtion, he rows but after 3 Miles an Hour and the Stream ſet after $2\frac{1}{2}$ Miles an Hour, then he muſt row 341 $\frac{6}{10}$ Poles, to go ſtreight over.

Laſtly, for the Time.

Three Miles are 960 Poles; ſay then,

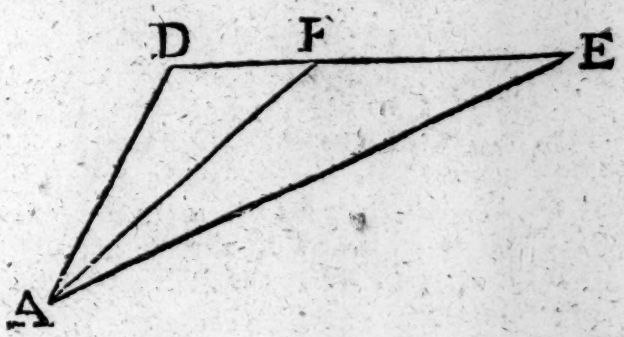
As the ſimple hourly Motion	960	7.017729
To the ſimple Motion before found	341 $\frac{6}{10}$	2.533517
So is an Hour in Minutes, namely,	60 min.	1.778151
To the time required in Minutes	21 $\frac{35}{100}$	1.329397

And thus it appears, that the Time requiſite to row over, rowing 3 Miles an hour, is 21 $\frac{35}{100}$ minutes; whereas we found before that rowing there $4\frac{1}{2}$ miles an hour, they might row over in 5 $\frac{35}{100}$ minutes, which is a little more than a fourth part of the Time.

There might be other, and that a great Variety of Queſtions of this Nature propoſed and reſolved, many of good uſe in Practice, which the Watermen by daily Experience, without other Rules, are able to gueſs at ſomething nearly, ſufficing for their Occaſions: My Intent in theſe eſpecially, is to explicate the compound Motion of a Ship, or other Veſſel, ſailing or rowling where there is a Current; which by ſuch familiar Examples may ſeem more evident. I cannot

not inſiſt upon them by Reaſon of my other occaſions, nor ſpend that Time in theſe here handled, which elſe I ſhould have done; whence if any Defect or Miſtake ſhould ariſe, if the Reader be pleaſed to give me friendly Notice of it I ſhall as thankfully accept it, and reform it. We purpoſe next a Queſtion at Sea, which let be this,

11. *There is a Current at Sea, ſetting Exact* 12 *miles in* 24 *hours, a Ship ſails in the time from a certain Port Weſt South Weſt ſix days; and then returning thence, and ſailing North Eaſt and by North three days, falls with the Port from whence ſhe firſt departed: I demand what her Dead Reckoning was outwards, and what back again; and how far theſe two Ports were aſunder, and upon what Point of the Compaſs?*



As let the Current ſet from E towards D, and let the firſt Port be A, the ſecond F, and let the Courſe Outward bound be repreſented by A E, and the Courſe homeward by DA, &c.

And foraſmuch as D E is an Eaſt and Weſt Line, and A E Weſt South Weſt, therefore the Angle at E is 22 deg. 30 min. and by the like Reaſon, the Angle at D is 123 deg. 45 min. or 56 deg. 15 min. and the Angle at A 33 deg. 45 min. and ED being the ſetting of the Current for 9 days, is 108 miles.

Firſt then, for the Dead Reckoning outwards, namely, AE.

As the Sine of the Angle to *Aſ.* 33 deg. 45 min.	0.255261
To the Line DE 108 miles	2.033423
So is the Sine of the Angle D*ſ.* 56 deg. 15 min.	9.919846
To the Line AE $161\frac{6}{10}$ miles	2.208530

Thus AE his Dead Reckoning outward is $161\frac{6}{10}$.

Secondly, for AD.

As the Sine of the Angle BAE, *ſ.* 33 deg. 45 min.	0.255261
Is to the Line DE 108 miles	2.033424
So is the Sine of the Angle DEA, *ſ.* 22 deg. 30 min.	9.582840
To the Line AD $74\frac{4}{10}$ miles	1.871525

Which $74\frac{4}{10}$ miles is the dead Reckoning homewards.

Thirdly, for the Angle DAF *or* DFA;

The ſide AD is found	74 $\frac{4}{10}$ miles	
The ſide DF for 3 days is	36 miles	
The Sum of both is	110 $\frac{4}{10}$	
Their difference is	38 $\frac{4}{10}$	
The Sum of the Angles DAF and DFA	56 deg. 15 min.	
The half Sum is	28 deg. 7 $\frac{1}{2}$ min,	

The Proportion.

As the Sum of their ſides	110 $\frac{4}{10}$	7.957031
Is to their difference	38 $\frac{4}{10}$	1.584331
So is the Tangent of	28 deg. 07 $\frac{1}{2}$	9.727804
To the Tangent of	10 deg. 32 min.	9.269166

Which added together, makes the Angle DFA 38 deg. 39 min. $\frac{1}{2}$.

And ſeeing the Rhomb from F to D, is Eaſt, and the Angle DFA 38 degrees 39 minutes $\frac{1}{2}$; therefore the Rhomb from F to A is to the N.wards of the Eaſt 38 degrees 39 minutes $\frac{1}{2}$; that is N. E. by E. almoſt half a Point Northerly; which is the Rhomb from the ſecond Port to the firſt.

Laſtly, for AF *the Diſtance of theſe two Ports.*

As the Sine of the Angle	DFA/. 38 deg. 39 $\frac{1}{2}$	2.04425
To the dead Reckoning homewards	AD 74 $\frac{4}{10}$ miles.	1.871572
So is the Sine of the Angles	D/. 56 degrees 15 minutes	9.919846
To the Diſtance	AF 99 $\frac{1}{100}$ miles.	1.995843

Then the true Diſtances of thoſe two Ports is 99 miles and ſomewhat more. Sundry other Queſtions of like Nature might be propoſed, which to him that well underſtands theſe will not be difficult. Theſe Principles a little enlarged may further with a few Experiments, be applied in the diſcovery of ſome Myſteries in compound Motion, not yet divulged, though much endeavoured by ſundry famous Men in ſeveral Parts of *Europe*; but theſe we ſhall not touch at preſent.

12. *To find where there is a Current at Sea; alſo which way it ſets, and how faſt.*

This may be done by comparing the Reckonings outwards with the Reckonings homewards, whereof we ſhall give an Example or two.

Firſt, As admit a Ship ſail from a certain Port, by one or ſeveral Rhombs or Diſtances, till ſhe arrive at the ſecond, and there find, reckoning by Courſe and Diſtance, that ſhe is more ſoutherly than the Port from which ſhe departed from by

by 541 Miles, and more Westerly by 145 Miles: But by his Reckoning homewards, when he arrives again at the first Place, he finds himself to the Northwards of the second 541 Miles, as before, and to the E.ward 305 Miles. Now supposing he was three Day outward bound, and five Days homewards bound, I will know which way the Current sets, and how fast: Here because the Easterly distance homewards is greater than the Westerly distance outwards, therefore from the Easterly distance 305 Miles, subtract the Westerly distance 145 miles, the Remainder being 160 Miles, is the Motion of the Current to the Westwards.

And thus it appears, that the Current sets to the Westwards 160 Miles in 8 days, that is 20 Miles a day, or $\frac{5}{6}$ of a Mile every hour.

Example 2. Admit a Ship sail from *Bermudus*, by several Rhombs and Distances, till she arrive at *Cape Cod* in *New England*, namely, from the East part of *Bermudus* (the Variation being allowed) first North 20 Miles, and then N N W. 150 Miles, the second day N by W. 180 Miles, the third day North 90 Miles, the fourth day N E. 88 Miles, and so arrive at *Cape Cod*. Then by these Courses and Distances we may gather by the following Table, that *Cape Cod* should by this Reckoning be to the Northwards 487 Miles, and to the Westwards 30 Miles, as here appears.

	North	*South*	*East.*	*West*
North 20 Miles	20 0			
North North West 150 Miles	138 6	—	—	57 4
North by West 180 Miles	176 5	—	—	35 1
North 90 Miles	90 0			
North East 88 Miles	62 2	—	62 2	
528 Miles	487 3		62 2	92 5
				62 2
				30 3

Now suppose she sail back again from *Cape Cod* towards *Bermudus*, the first day S S W. 150 Miles, the next day S S W. 160 Miles, the third day S by W. 130 Miles, the fourth day South 140 Miles, the fifth day East 110 Miles, and so she come again to the East Part of *Bermudus*.

	North	*South*	*East*	*West.*
South S W. 150 Miles	—	138.6	—	57.4
South S W. 160 Miles	—	147 8	—	61.3
South by W. 130 Miles	—	127.5	—	25.3
South 140 Miles	—	140.0	—	—
East 110 Miles	—	—	110.0	—
690 Miles	—	554.0	110 0	144.0
				110.0
				34.0

These

These Courſes and Diſtances make as here appeareth, *Bermudus* to be to the Southwards of Cape *Cod* 554 miles, and to the Weſtwards 34 miles.

Therefore by this laſt Reckoning back again, *Cape Cod* ſhould be to the Northwards of *Bermudus* 554 miles, and to the Eaſtwards 34 miles, whereas by the former Reckoning outwards, it was to the Northwards only 487 miles, and to the Weſtwards 30 miles; ſo that the Difference of theſe two Reckonings outward and back again, is 67 miles Northerly, and 64 miles Eaſterly; which ſheweth that the Current in that time, namely, in 9 days, and hath ſet to the Northward 67 miles, and to the Eaſtward 64 miles; that is North East a little Northerly 93 miles, as by the foregoing Table doth appear, which is $10\frac{3}{9}$ miles every day.

And what we have here done by the Tables, might have been done (as the foregoing Problems) by the *Doctrine of Plain Triangles.*

F I N I S

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